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INDEX

Dichromatic absorption radiography. Dichromography. By *Bertil Jacobson* 437
Urethrography in the male. By *O. Morales* and *R. Romanus* 453
A study of the iodine-concentrating function of the thyroid after treatment with radioactive iodine. By *Lars-Gunnar Larsson* and *Inger Ragnhult* 477
The Troell-Junet syndrome. By *Sherwood Moore* 485
The elimination of errors in roentgen microradiography. By *S.-O. Brattgård, O. Hallén* and *H. Hydén* 494
A time-marker for urograms. By *Olof Willner* 499
A simple method of ensuring correct concentration of barium contrast media. By *Ove Mattsson* 501
Proceedings of the 17th Congress of the Northern Association of Medical Radiology 507
Proceedings of the 18th Congress of the Northern Association of Medical Radiology 514
Book reviews 519

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VOL. 39 JUNE 1953 FASC. 6

DICHROMATIC ABSORPTION RADIOGRAPHY. DICHROMOGRAPHY

by

Bertil Jacobson

Introduction

An important problem in modern radiology is to increase the contrast obtained in a radiograph. The present work will deal with the possibility of using essentially monochromatic roentgen rays for this purpose. We shall also briefly discuss the quantitative determination of elements of high atomic number, such as iodine, in a non-destructive biochemical analysis for studies in vivo. This investigation actually was first undertaken to find out whether the ingenious methods of ENGSTRÖM for the ultramicro-determination of elements with monochromatic roentgen rays could be applied to macro-biochemical problems. In the course of the work, however, it appeared that the employment of monochromatic roentgen rays was useful also for pure radiology. CLARK has discussed the application of essentially monochromatic roentgen rays to medical and industrial radiology.

By the term dichromatic absorption radiography is meant the technique of using the differences of absorption of two or several monochromatic roentgen rays or rays of different wave-length distributions for the production of a picture showing differences in absorption or for showing the distribution and/or the concentration of an element in an object. Dichromography will be used here as an abbreviation of dichromatic absorption radiography.

The intention has not been to construct a complete apparatus ready for practical use, but to investigate the practical possibilities for such a construction and to discuss the possible use and development of the technique mentioned above.

Submitted for publication, March 3, 1953.

From the Biochemical Department (Director: EINAR HAMMARSTEN), Karolinska Institutet, Stockholm, Sweden.

Basic Theory

The amount of roentgen energy absorbed is determined by the wave-length of the radiation, the thickness and elementary composition of the absorption layer. The intensities I_0 and I of the incident and transmitted rays are related by

$$I = I_0 e^{-(\mu_1 x_1 + \mu_2 x_2 + \ldots)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where μ_n is the mass absorption coefficient of the elements n in the absorbing layer and x_n the corresponding mass in g/cm². The mass absorption coefficients for an element depends on the wave-length of the radiation. In general the absorption increases with the wave-length but at certain wave-lengths absorption edges occur as is illustrated in Fig. 1 (see SPROULL or COMPTON and ALLISON). There are two possible methods of using these absorption phenomena for practical dichromographic purposes.

Edge dichromography. By measuring the difference in absorption of two wave-lengths, λ_1 and λ_2 in Fig. 1, lying close to but on opposite sides of the absorption edge of a certain element, its concentration can be determined (ENGSTRÖM). The absolute intensities of the two rays are of minor importance for analysing purposes. Of larger interest are the ratios between the intensities of incident and transmitted rays and which must be known for an exact quantitative determination of the element. However, for a qualitative or quantitative analysis using a calibration procedure it is enough to know the ratio or the difference of the intensities of the two transmitted rays, assuming that the intensities of the incident rays are made equal (Fig. 2). This ratio or difference is a function of the concentration of the element, the function also including the total absorption of the layer. As the total absorption can be experimentally normalized in several ways (see below) it is thus possible to obtain at least a semiquantitative estimation of the concentration of an element in the manner described. The method is limited to elements of high atomic number, such as iodine, due to the fact that the wave-lengths of the K-absorption edge correspond to roentgen rays too

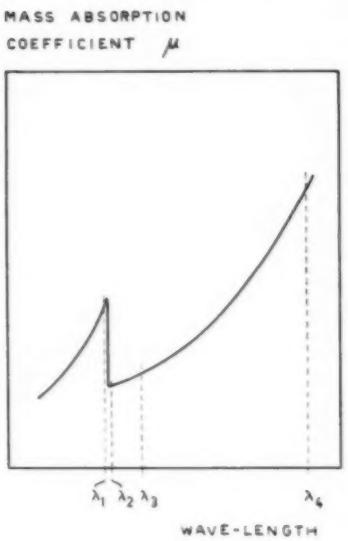

Fig. 1.

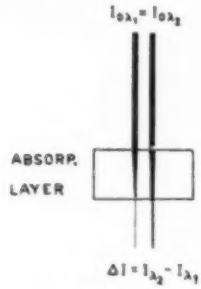

Fig. 2. Principle of edge dichromography.

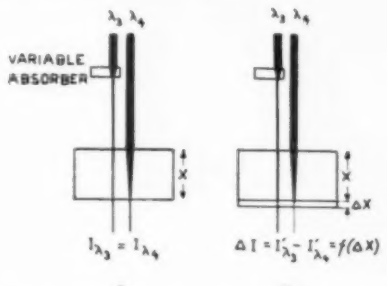

Fig. 3. Principle of continuous dichromography.

soft for the lighter elements to be of a practical use in macroradiography. For an experimental realization of this "edge dichromography", which should show the distribution and eventually also the concentration of a certain heavy element in an object, it is thus necessary to produce monochromatic roentgen rays of the proper wave-lengths and intensities. Further the measured intensity differences or ratios of transmitted rays must be mapped automatically in order to give a picture of the element distribution.

Continuous dichromography. Due to the difficulty of observing small differences in film densities, the accuracy of measuring absorption differences in ordinary radiography is limited. The use of roentgen rays of various wave-length offers a method of increasing the possibilities of observing small absorption differences in adjacent areas in the following way. Two highly differing wave-lengths λ_3 and λ_4 (Fig. 1) are chosen and the intensity of the harder ray is primarily reduced to such an amount that, when the two rays have passed through the absorption layer in a certain area (Fig. 3 A), they will be equal. If the absorption in an adjacent area (Fig. 3 B) is larger (smaller) the intensity of the softer ray will be more reduced (less reduced) than that of the harder. As it is easier experimentally to measure accurately the difference of intensities than to measure absolute intensities, this "continuous dichromographic" method offers a possibility of studying small differences in absorption in adjacent areas of an object. As was the case in edge dichromography, it is necessary to produce roentgen rays of certain wave-lengths of the proper intensities, to measure the intensity difference of the transmitted rays and to map out the differences to produce a picture.

Production of Monochromatic Radiation

Monochromatic roentgen rays can be obtained in several ways. Strictly monochromatic radiation is obtained when a polychromatic

spectrum is diffracted by a crystal. The intensity of this monochromatic radiation is at the present stage of technical development probably too small to be of practical use here. If a certain element is used as a target in a roentgen tube, characteristic emission lines superimposed on a continuous spectrum are obtained. This method thus gives a mixed radiation and has further the disadvantage that only very few elements, due to the factors of too low melting and boiling points, can be used as targets. The third method is to use the characteristic fluorescent radiation or so called secondary radiation obtained when an element is irradiated with a continuous roentgen spectrum of sufficient hardness. In this case a mixed radiation is also obtained but the intensity of the continuous part is only a small fraction of that of the characteristic one if the primary radiation has the proper wave-length distribution (SPROULL, ROGERS). This third method was considered to be the best and only possible technique at the present time. To find out whether the secondary radiation was monochromatic (homogeneous) to a sufficient degree and to see if intensities high enough could be obtained for practical use in this investigation, a preliminary experiment was carried out. (To Dr. S. LEDIN at *AB. Georg Schönander* the author is indebted for much assistance with this experiment.)

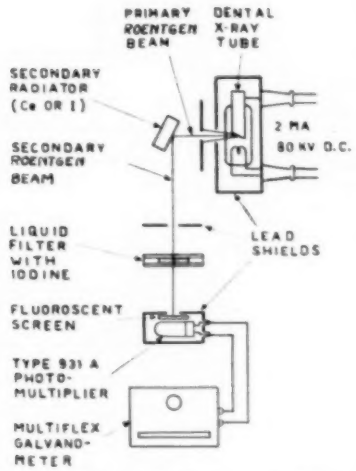

Fig. 4. Schematic diagram of the preliminary experimental arrangement.

Samples of different compounds were irradiated at a distance of 10 cm from the tungsten target of an ordinary dental roentgen tube operated at 3 ma and 80 kv. The surface irradiated was 0.2 × 1.0 cm. The intensity of the secondary radiation was determined in the following way. At a distance of 12 cm from the secondary radiator, a Patterson B 2 fluorescent screen was placed close to a 931-A photomultiplier tube and the current from the latter was measured with a galvanometer (Fig. 4). Filter cells of equal thickness but containing different concentrations of iodine in water were placed between the secondary radiators and the fluorescent screen. Cerium and iodine were chosen as secondary radiators because their K-characteristic emission lines are in the vicinity of the K-absorption edge of iodine (Fig. 5). The results of the measurements are seen in Fig. 6.

The total intensity of the secondary radiation was of such a magnitude that it was considered to be useful for practical dichromographic purposes because the current obtained in the photomultiplier was large compared with its dark current (0.02 μA). The intensity of the secondary radiation, measured by the multiplier current, was 0.002 times that of the primary radiation measured in the same way and under identical conditions.

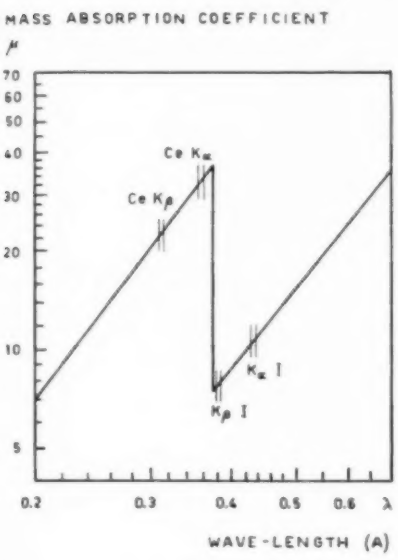

Fig. 5. Mass absorption coefficient of iodine as a function of the wave-length. Characteristic emission lines of cerium and iodine also shown.

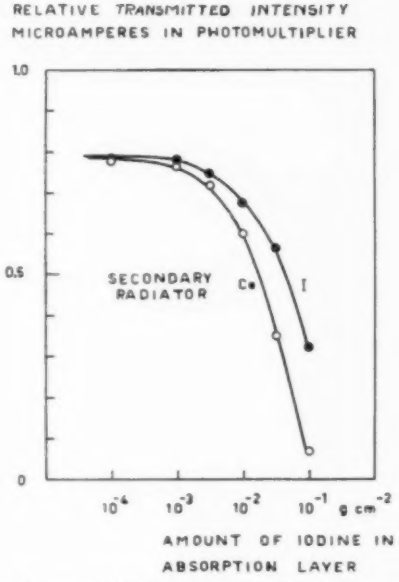

Fig. 6. Relative roentgen intensity as a function of the amount of iodine in absorption layer.

In Fig. 7, a recalculation has been made of the data presented in Fig. 5. The ratios of the transmitted intensities, calculated for equal incident intensities, have been plotted as a function of the amount of iodine in the absorption layer. The full line is calculated with $\mu_1 = 25$ and $\mu_2 = 9$ which are reasonable average values for the mass absorption coefficients of iodine for the cerium and iodine K-characteristic radiations. The agreement between experimental and calculated values indicates that the secondary radiation can be regarded as essentially monochromatic (homogeneous) for dichromographic purposes. These results are in agreement with those obtained by ROGERS on the secondary radiation from lighter elements. Fortunately, the K-emission lines of the elements are so situated that any desired wave-length above 0.1 Å can be obtained by selecting the right element as a secondary radiator.

Wave-length Wobbling and Scanning Apparatus

An apparatus was constructed to produce a picture showing absorption differences in an object as described above. The major components comprise a roentgen tube with high tension supply, a rotating system of secondary radiators, a system for the adjustment of roentgen intensities, an object table, a fluorescent screen and photomultiplier combination,

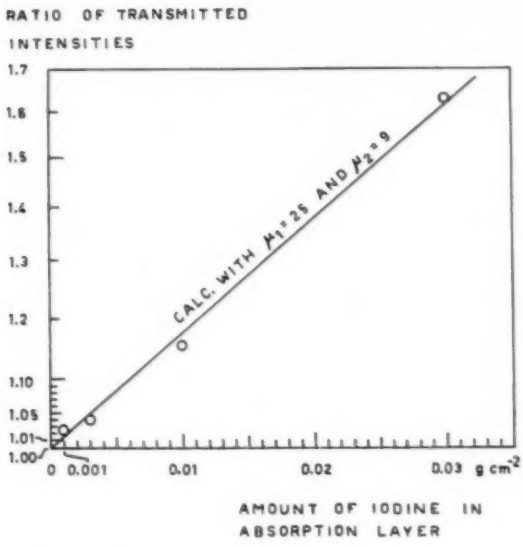

Fig. 7. Intensity ratios of the two transmitted beams as a function of the amount of iodine in absorption layer. The mass absorption coefficients $\mu_1 = 25$ and $\mu_2 = 9$ correspond to the wave-lengths $\lambda_1 = 0.32$ and $\lambda_2 = 0.41$ Å. Experimentally found values obtained with cerium and iodine as secondary radiators.

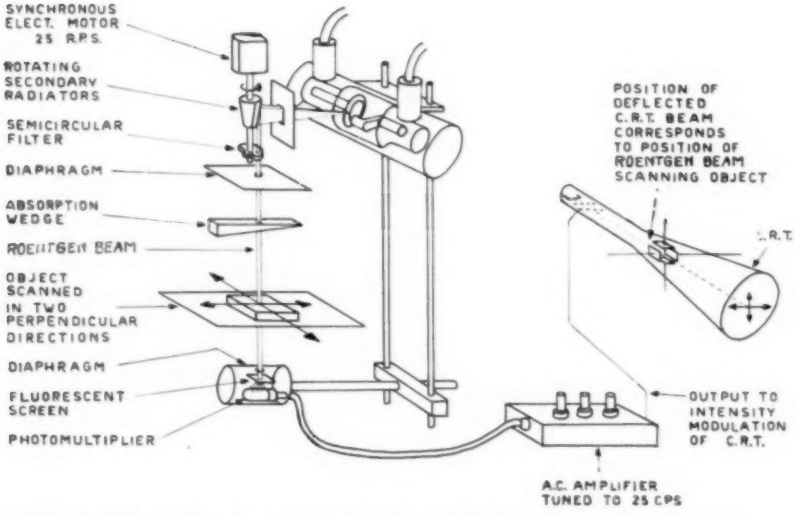

Fig. 8. Schematic view of wave-length wobbling and scanning apparatus.

amplifiers, two cathode ray oscillographs one being supplied with a camera, and a system for scanning the object with the roentgen beam. A schematic diagram is given in Fig. 8.

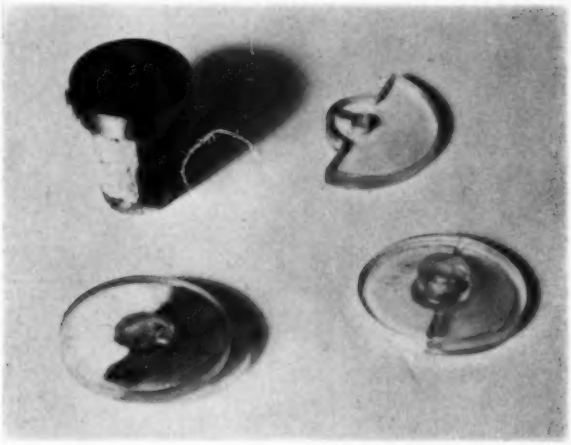

Fig. 9. Rotating secondary radiator and semicircular filters.

The high tension supply gave 0—6 ma at 80—92 kv. To obtain a smoothed d. c. voltage, 1 μF condensers were connected to each side of the symmetrically grounded output. As no stabilization of the high tension supply was used, the fluctuations in the primary current in the high tension transformer were 20 %, due mainly to line voltage fluctuations.

Because a roentgen tube with a rotating target gave the shortest possible distance (3 cm) between target and secondary radiator, it was chosen to generate the primary roentgen rays. The radiators had the shape of the frustum of a cone, each of the two radiators covering half the curved surface (Fig. 9). The secondary radiator material was an oxide or sodium salt of the element desired. The surface irradiated with the primary beam was 0.5 × 2.0 cm and the projection of the surface in the direction of the secondary radiation used was 0.5 × 0.5 cm. The radiators were rotated with 25 r. p. s. giving a wave-length wobbling with the same frequency.

In order to adjust the intensity of the two secondary beams a combination of rotating semicircular filters and a wedge filter was used. The semicircular filters served to give approximately the right intensity and to make the radiation more homogeneous. This was attained by using a filter element having its K-absorption edge between the K_α and K_β emission lines of the secondary radiator. The K_β intensity was thus much more reduced than the K_α intensity, thereby leaving a secondary radiation consisting mainly of the K_α wave-length. The wedge filter could be moved perpendicularly to the direction of the roentgen beam, thus enabling a continuous variation in filter thickness. The absorbing element in the wedge filter was chosen so that the absorption of the two wave-lengths was greatly different. With such a combined filter system it was always possible to obtain desired intensity ratios in a simple manner.

A narrow roentgen beam for scanning the object, using two diaphragms, was obtained (Fig. 8). The hole in the diaphragm in front of the fluorescent screen had a diameter of 0.3 cm. Because the object was placed close to this diaphragm its size determined the resolving power of the scanning system.

A Patterson fluorescent screen Type B 2, at a distance of 16—20 cm from the secondary radiators, was fixed by tape close to the glass envelope of the 931-A photomul-

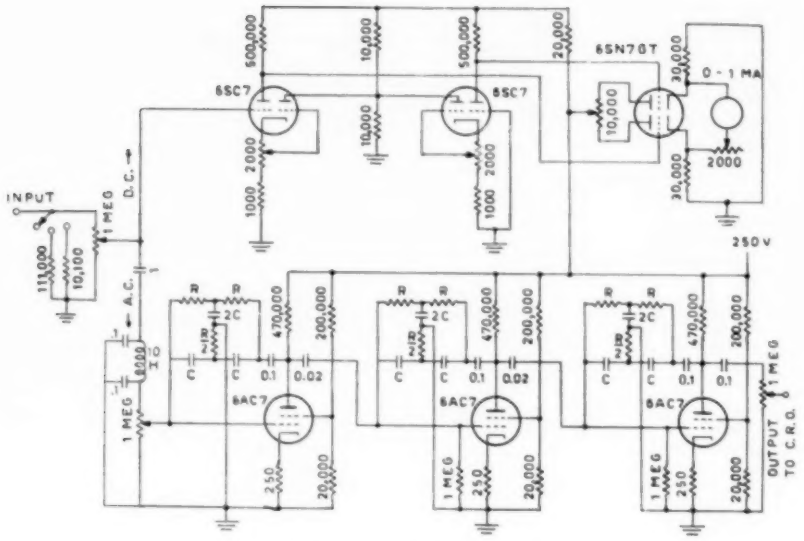

Fig. 10. Amplifier circuit.

tiplier tube. The 900 volt supply to the latter was regulated by a conventional stabilizing circuit. The current from the multiplier was amplified in a d. c. amplifier and an a. c. amplifier, the circuits of which are given in Fig. 10. As one main problem in dichromography is the amplification of photocurrents, the amplifiers will be discussed in some detail.

The d. c. amplifier amplifies the d. c. component of the multiplier current which is in the order of 10^{-7} to 10^{-6} amp. or about five to fifty times the dark current. This low current ensures stable operation of the multiplier. A knowledge of the d. c. current is necessary for the determination of (or correction for) the total absorption in the case where the object is investigated with edge dichromography. The amplifier is a balanced MILLER circuit which gives excellent linearity and negligible drift. The a. c. amplifier is tuned to the wave-length wobbling frequency 25 c. p. s. It amplifies the 25 c. p. s. component of the multiplier current which is proportional to the intensity difference of the two transmitted wave-lengths. The amplifier consists of a three stage BOWERS circuit. The parallel-T feedback filters are tuned to 24, 25 and 26 c. p. s. which is necessary for stable operation in case the wobbling frequency changes slightly. The maximum amplification is 20,000 at 25 c. p. s. and is 40 at 100 c. p. s. This makes the amplifier insensitive to hum, and it is actually so selective that the roentgen tube can be supplied with a pulsating d. c. current as obtained when no condensers are used. Condensers were used, however, to increase the primary roentgen intensity and to reduce the influence of line voltage fluctuations. The high selectivity of the amplifier is also necessary in order to reduce the dark noise of the multiplier. Now only the 25 c. p. s. component of the dark noise is amplified and it amounts to only 10^{-10} amp. This current constitutes a limit for the accuracy of the dichromographic method with the present amplifier. If

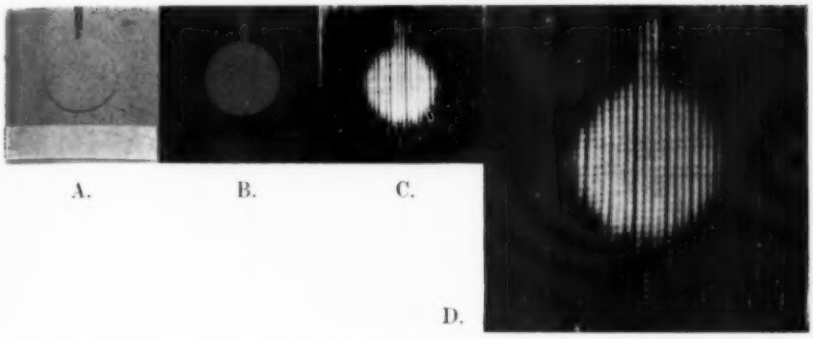

Fig. 11. A. Photograph of plexiglass cell containing 10 mg iodine per cm²
B. Ordinary radiograph at 45 kv.
C. Edge dichromographic picture of cell (3 ma 80 kv), cerium and iodine secondary radiators and amplifier gain of 6,000.
D. Enlargement of C.

the total current in the multiplier is 10^{-7} amp. this dark noise corresponds to an error of 0.1 % in measured intensity differences.

The output voltage from the a. c. amplifier, measured on one cathode ray oscillograph, intensity modulates the cathode ray of another which gives the picture of the scanned object. The scanning movement in one direction is made by means of an electric motor at a velocity of 2 cm/sec. In the other direction the scanning is made manually by a screw system giving spacings of 1 mm between the lines. The scanning movement is connected to potentiometers delivering voltages to the deflecting plates of the cathode-ray tube in such a manner that the cathode-ray beam scans the screen in the same way as the roentgen beam scans the object. The screen is photographed during scanning.

In order to illustrate some main difficulties and the limitations of the method, a few pictures are shown in Fig. 11—15. In Fig. 11 a typical edge dichromographic picture is shown for an iodine filter containing 10 mg iodine per cm². The plexiglass cell forming the filter had the dimensions of $3.5 \times 3.5 \times 0.8$ cm and the diameter of the iodine area was 1.5 cm. Pictures similar to that given in Fig. 11 may easily be obtained if the iodine content is 5 mg/cm² or higher. In the magnified picture the details of the scanning lines can be seen. The wave-length wobbling gives the lines a structure like a string of pearls, each bright point corresponding to half a period of the 25 c. p. s. multiplier current. This clearly illustrates that the wobbling frequency actually determines the upper limit of the permissible scanning velocity. By defocussing the cathode-ray tube or the camera the line structure of the picture may be removed (Fig. 13 D).

To detect small iodine quantities, the amplifier gain must be increased to such an amount that the electrical interference level gives the originally

A. B. C.

Fig. 12. A. Photograph of cells with 10, 5, 3 and 1 mg iodine per cm² (upper left, upper right, lower left and lower right respectively)
B. Ordinary radiograph at 45 kv.
C. Edge dichromographic picture (3 ma 80 kv), cerium and iodine secondary radiators and amplifier gain of 8,000.

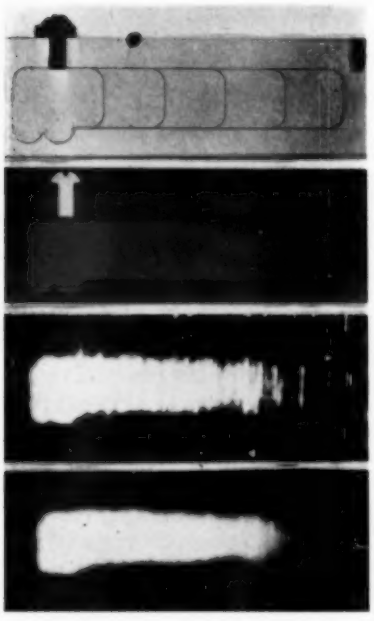

Fig. 13.

A. Photograph of cell containing 10, 8, 6, 4 and 2 mg iodine per cm² in steps from left to right.

B. Ordinary radiograph at 45 kv.

C. Edge dichromographic picture taken under the same conditions as in Fig. 12 C.

D. Defocussed dichromographic picture.

dark background a mottled appearance. (Fig. 12 and 13.) The very high interference level in the present experiments makes the smallest possible detectable iodine quantity 1 mg/cm². By a simple stabilization of the

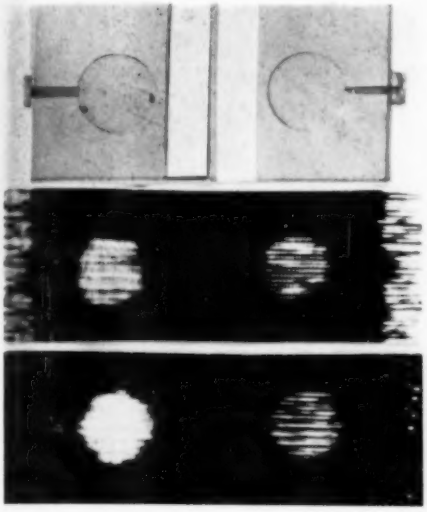

Fig. 14.

A. Photograph of cells containing 5 and 3 mg iodine per cm² (left and right respectively)

B. Edge dichromographic picture (3 ma 80 kv), cerium and iodine secondary radiators and amplifier gain of 8,000. Note bright margins caused by undesired continuous dichromographic effect.

C. Edge dichromographic picture at 3 ma and 80 kv, cerium and barium secondary radiators and amplifier gain of 8,000. No continuous dichromographic effect obtained.

roentgen tube power supply it should be possible to reduce this limit by a factor of about ten or more.

As is seen in Fig. 13, no large difference in brightness is obtained in the photographed dichromographic picture between 10, 8 and 6 mg iodine per cm². However, differences can clearly be seen when the cathode-ray screen is viewed directly. With a better photographic technique and, what is still more important, using a television tube in place of an oscilloscope tube, a much better result is probable.

It is obvious that even if the two wave-lengths λ_1 and λ_2 are close to each other in edge dichromography, the difference in wave-length causes an undesired continuous dichromographic effect due to the presence of large amounts of unsought for elements. This is illustrated in Fig. 14 B taken with cerium and iodine as secondary radiators in iodine edge dichromography. The bright margins are caused by an undesired continuous dichromographic effect when the scanning beam leaves the plexiglass cell. In this experiment the intensities of the two incident wave-lengths were not exactly equal, as stated in the theoretical section, but so adjusted that the difference in absorption in the plexiglass cell is compensated for. In the case of cerium and iodine as secondary radiators a thickness difference of 1 g plexiglass per cm² corresponds to about 5 mg iodine per cm² in the intensity differences obtained. However, if iodine as a secondary radiator is replaced by barium, which has its K_α emission line closer to the iodine absorption edge than iodine has,

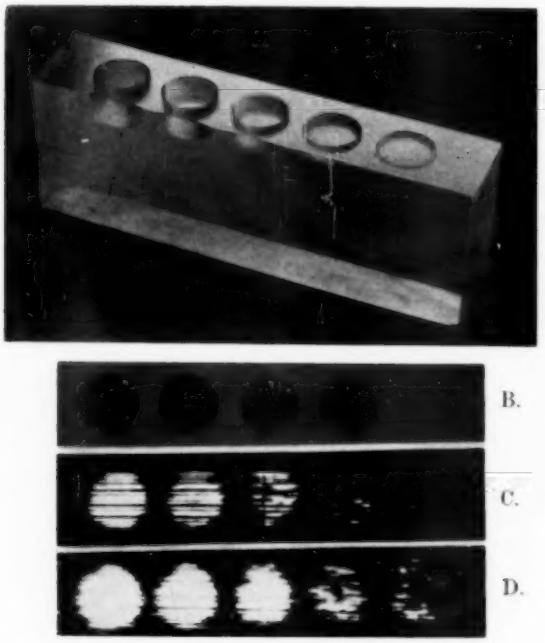

Fig. 15. A. Photograph of plexiglass object. Total height 4.1 cm and depths of holes of 1.0, 0.8, 0.6, 0.4 and 0.2 cm.

B. Ordinary radiograph at 65 kv.

C. Continuous dichromographic picture (6 ma 92 kv), tungsten and silver secondary radiators, multiplier diaphragm 0.3 cm in diameter and amplifier gain of 16,000.

D. Continuous dichromographic picture (6 ma 92 kv), tungsten and silver secondary radiators, multiplier diaphragm 0.5 cm in diameter and amplifier gain of 20,000.

an improvement is obtained, as is seen in Fig. 14 C. In this case 1 g plexiglass per cm^2 corresponds to 0.5 mg iodine per cm^2. With correctly chosen rotating semicircular filters, which make the scanning roentgen rays more homogeneous, this undesired effect may be further diminished. The reason why barium has not always been used is that the wave-length of its K_β emission lines is shorter than that of the iodine absorption edge. This results in a slightly lower sensitivity for the detection of iodine.

In the experiments with the continuous dichromographic technique, different secondary radiator combinations, such as tungsten-barium,

tungsten-silver and cerium-silver, have been used. To take full advantage of the principle, a large difference in the atomic numbers of the two secondary radiators is necessary. Thus tungsten-silver principally gave the best results. Unfortunately the intensity from the tungsten was very low, mainly due to the fact that the maximum high tension available was 92 kv. This voltage is at least 10 kv too low for a good intensity yield, and as a result of this the quality of the pictures obtained was poor. This was due mainly to the necessity of increasing the multiplier diaphragm aperture to 0.5 cm in some experiments to compensate for the low intensity. The multiplier d. c. current was in spite of this only 3 times its dark current. However, Fig. 15 illustrates the increase in contrast which may be obtained with the method. It should be observed that with the present apparatus both an increase and decrease in absorption is reproduced brightly in the picture as compared with the black area where the transmitted intensities were made equal. If only negative or positive absorption differences are required to be reproduced in the picture, it should be possible to obtain these by a blocking of the amplifier synchronously with the wobbling frequency when one of the transmitted rays is larger than the other. As the practical problems with continuous dichromography are much the same as those with edge dichromography no further discussion is necessary.

Applicability

It should be possible to use the technique described here in different problems as a complement to ordinary medical and industrial radiography. Amongst macro-biochemical problems, quantitative edge dichromography should be limited to studies of iodine metabolism of the thyroid. Further, as a practical apparatus designed for quantitative analysis would be rather complex, the methods discussed in this work will possibly be more used in the form of qualitative edge dichromography and continuous dichromography. The use of iodine compounds or compounds with other heavy elements as contrast mediums offers possibilities of attacking problems in medical radiography which hitherto have been difficult to study.

Of importance for medical applications is the amount of roentgen energy absorbed during the exposure. Due to the high sensitivity of modern multiplier tubes, the roentgen intensity needed for registration is only a small fraction of that needed in fluoroscopy. And as only a very narrow roentgen beam passes a certain area during a very short period of the scanning time, the total number of roentgen units is only a small fraction of those utilized in ordinary radiography. This is true even for the soft roentgen rays used in iodine edge dichromography.

The main advantage of the methods discussed is the sensitivity to small absorption differences. The main disadvantage with the pictures obtained is that sharp boundaries will not be obtained in the same way as in ordinary radiography.

Developmental Possibilities

The construction of an apparatus for practical use offers several interesting problems. The necessity of a stabilized power supply has been mentioned above. No standard roentgen tube could be used with advantage. In order to obtain the necessary intensity of the secondary radiation the tube should be so constructed that the radiators can be placed very close to the target. The focal spot of the tube should preferably be large (several cm^2) to allow for high currents. Liquid cooling of the target is also essential. Further, the tube should be given a shape, *e. g.* that of a right angle, facilitating the placement of the secondary radiators and filtering system. Scanning in the rapid direction should preferably be made through movement of the diaphragms instead of the whole system including roentgen tube and multiplier. In order to maintain high constant primary roentgen intensity on the secondary radiator surface used momentarily, the electron beam in the roentgen tube could be made to scan the large target synchronously with the scanning movement of the diaphragms. If the wobbling frequency is chosen high, *e. g.* 2,500 c. p. s., a scanning velocity of 2,500 cm/sec. can be used. This velocity should be sufficient for most radiographic problems. A very large increase in primary roentgen intensity can be obtained through pulsed operation of the tube. It is possible that an increase in sensitivity of the methods could be obtained with such an arrangement in combination with a pulse lengthener in the amplifier. However, the result also depends on several other problems, not yet investigated such as the behaviour of pulsed operated fluorescent materials.

To compensate for the variation in the total absorption in a scanned object the amplifier could be supplied with an automatic amplification control.

The use of more than two monochromatic beams makes possible an automatic compensation for the total absorption in the object in, for instance, quantitative edge dichromography. Each of the secondary radiating surfaces, the total number being a multiple of four, can contain two elements in such a way, and in such a combination, that two pairs of wave-length wobbled beams scan the object simultaneously in the same area. The wobbling frequency of one wave-length pair is a certain multiple of the other. The two resulting mixed multiplier currents can be separated in two parallel amplifiers tuned respectively to the two

wobbling frequencies. One wave-length pair or 'channel' is used for the picture production. The other may be used for, for instance, an automatic control of a wedge filter. Several other applications of such multi-wobbling frequency systems are possible.

Thus there seems to be possibilities for the construction of equipments intended for practical use.

Acknowledgement

The author acknowledges the personal interest shown by the late Professor ERIK LYSHOLM in the practical possibilities of the method and which has been of great importance for the accomplishment of this work.

To Professor ARNE ENGSTRÖM the author is indebted for much assistance and for the never-failing interest in his problems. Warm thanks are due to Professor KNUT LINDBLOM for helpful criticisms and permission to take the ordinary radiographs in the Roentgen Department of Karolinska Sjukhuset.

Great aid for this investigation has been obtained from the laboratory resources put at the disposal of the author by *AB Georg Schönander*.

SUMMARY

The use of monochromatic roentgen rays makes possible, firstly, the detection of small absorption differences in radiography and, secondly, the detection of small amounts of heavy elements and their distribution in living organs. The difference in the intensities of the two transmitted wave-lengths is measured and is mapped automatically on a cathode ray screen by a scanning procedure. Using the secondary radiation from selected elements, monochromatic roentgen rays can be obtained of the proper purity and intensity for practical purposes. Pictures obtained with the method show larger contrasts with small absorption differences or small amounts of contrast substances than ordinary radiographs. When fully developed, the method might be of value as a complement to ordinary radiography.

ZUSAMMENFASSUNG

Durch die Anwendung monochromatischer Röntgenstrahlung ist es möglich, sowohl kleine Absorptionsunterschiede in der Radiographie als auch die Menge und Verteilung von schweren Elementen im lebenden Organismus nachzuweisen. Der Unterschied der Intensität von zwei transmittierenden Wellenlängen wird duch eine "Scanning"-Prozedur auf einem Kathodenstrahlenschirm registriert und dargestellt. Durch die Verwendung der Sekundärstrahlung geeigneter Elemente kann man monochromatische Röntgenstrahlung erhalten, deren Reinheit und Intensität für die praktische Anwendung ausreichend ist. Die mit der beschriebenen Methode aufgenommenen Bilder zeigen stärkeren Kontrast für geringe Absorptionsunterschiede oder kleine Mengen von Kontrastmitteln als gewöhnliche Röntgenaufnahmen. Nach ihrer völligen Entwicklung müsste die Methode als Ergänzung zur üblichen Röntgenphotographie von Wert sein.

RÉSUMÉ

L'emploi de rayons roentgen monochromatiques permet, d'une part, de constater en radiographie l'apparition de petites différences d'absorption, d'autre part, d'étudier les quantités et la répartition des éléments lourds dans les organes vivants. La différence d'intensité sur deux longeurs d'onde transmises est enregistrée et, pour ainsi dire, cartographiée sur l'écran d'un tube cathodique par un procédé d'analyse dit *scanning*.

Le rayonnement secondaire émis par certains corps appropriés permet d'obtenir un rayonnement monochromatique d'une pureté et d'une intensité suffisantes pour l'usage pratique. Les radiographies obtenues par cette méthode mettent en évidence avec plus de netteté que les radiographies ordinaires les petites différences d'absorption et les infimes quantités de contraste. Une fois développée, cette méthode pourrait devenir un complément de valeur de la radiographie habituelle.

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URETHROGRAPHY IN THE MALE

Delimitation of the Anterior and Posterior Urethra, the Pars Diaphragmatica, the Pars Nuda Urethrae and the Presence of a Musculus Compressor Nudae

by

O. Morales and *R. Romanus*

In our publication, 'Urethrography in the male with a highly viscous, water-soluble contrast medium, Umbradil-Viscous U', we compared the results of roentgen examinations of the urethra. These examinations were performed during injection and contraction of the pelvic floor, both low and high viscosity media being used. We found that certain details in the roentgenograms could not be explained on the basis of the usual 'roentgen anatomy'. In this paper we shall describe in detail our investigation of the boundary area between the anterior and posterior portions of the urethra; this led to the roentgenologic demonstration of the *pars nuda* and *m. compressor nudae* and increased the possibility of their precise demarcation.

Anatomy. As the anatomy of this area is of significance for an appreciation of the motility of the posterior urethra (to be dealt with in a later paper), it must be described at some length. The description is mainly based on WALDEYER and HOLL, whose views appear to us to be the most comprehensive and best correspond to our own findings in a small number of dissections of this region (Fig. 1).

The *urogenital diaphragm* consists of a plate of tissue filling the so-called levator space anteriorly in the pubic arch. It is attached laterally to the fascia covering the obturator internus muscle on the pubic and ischial bones and thus not directly to the skeleton (Fig. 2 from VERNET).

According to HOLL the urogenital diaphragm is made up of a lamellar system of tendino-elastic fibres, attached to, or originating in,

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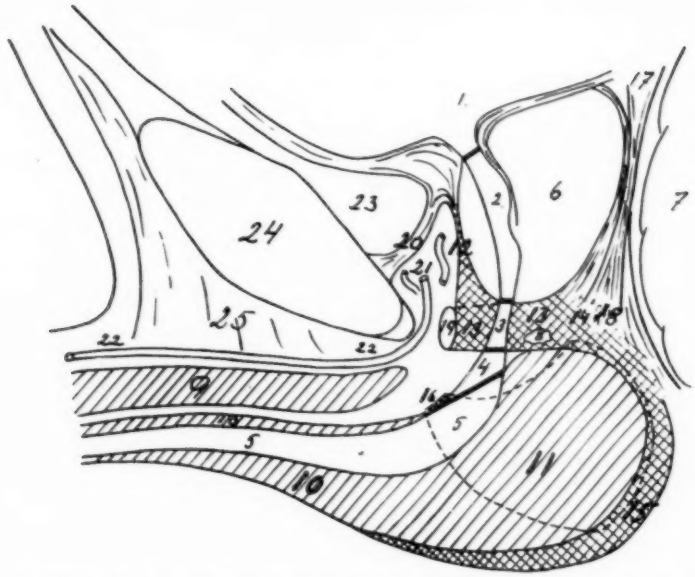


Fig. 1. Diagram of the anterior part of the pelvic floor, according to WALDEYER, slightly modified. 1. Urinary bladder. 2. Prostatic urethra. 3. Diaphragmatic urethra. 4. Pars nuda of the urethra. 5. Spongy portion of the urethra. 6. Prostate. 7. Rectum. 8. Bulbo-urethral gland of Cowper. 9. Corpus cavernosum penis. 10. Corpus spongiosum penis. 11. The bulb (of the spongy portion) of the penis. 12. External sphincter, prostatic portion. 13. External sphincter, diaphragmatic portion covered on the underside by the inferior fascia of the urogenital diaphragm (perineal membrane) (unbroken line). 14. Deep transverse perineal muscle. 15. Bulbo-spongiosus muscle with m. compressor nudae (broken line). 16. The tendinous plate of the m. compressor nudae on the anterior wall of the lowest part of the pars nudae urethrae. 17. Recto-genital septum (fascia Denonvilliers). 18. Perineal body. 19. Transverse perineal ligament of Henle. 20. Pubo-prostatic ligament. 21. Vesico-prostatic plexus of veins of Santorin. 22. Dorsal vein of the penis. 23. Prevesical space of Retzius. 24. Symphysis (with the inferior pubic ligament or the arcuate ligament). 25. Suspensory ligament of the penis. (The boundaries between the different parts of the urethra are drawn with heavy lines.)

neighbouring connective tissue, and merging at the upper and lower sides of the diaphragm with the fascial layers which delimit the deep perineal pouch. Bundles of muscles are situated in the partitions between the connective tissue lamellae in this pouch. They are the *external urethral sphincter* and *deep transverse perineal muscles*. These muscles are not, therefore, inserted directly into the bone, but are connected to it by means of the elastic connective tissue of the diaphragm. The urethra passes through the diaphragm slightly anteriorily to its

Fig. 2. Sagittal section through the urogenital diaphragm showing its lateral attachments (15 and 16) on the fascia of the obturator internus muscle (6). From VERNET. 1. Urinary bladder. 2. Levator ani muscle. 3. Fascia of the prostate. 4. Bottom of the perivesical space. 4^1. Fascia of the bladder. 5. Obturator internus muscle. 6. Fascia of the obturator internus muscle. 7. Superficial perineal plexus of vessels and nerves. 8. Diaphragmatic portion of the urethra. 9. External sphincter. 10. Bulb of the penis. 11. Bulbo-spongiosus muscle. 12. Ischio-cavernosus muscle. 13. Rami of the pubic and ischial bones. 14. Internal pudendal plexus of vessels and nerves. 15. Upper fascia of the deep perineal pouch. 16. Lower fascia of same.

centre. The narrowest portion of the urethra lies in this region and is more correctly termed the *pars diaphragmatica* than the pars membranacea. The wholly sealed deep perineal pouch also encloses the two bulbo-urethral glands of Cowper, situated dorsally of the pars diaphragmatica urethrae.

M. sphincter urethrae externus is a muscular unit but may be divided into two parts dependent on its position in relation to an imaginary upper diaphragmatic plane: a proximal prostatic and a distal diaphragmatic part. The proximal portion arises in front of the prostate at the boundary of the bladder, *i.e.* at the level of the so-called internal sphincter. It consists of transverse muscle fibres, which distally increase in number. According to the majority of authors they are attached at the sides of the prostatic sheath by means of fine tendons. The more distal the position of the prostate the more these fibres close around its sides, and at and below the prostatic apex they completely encircle the urethra. A section through the upper border of the sphincter lies at a slant to the urethra and inclines backwards and downwards whereas

a section through its lower part will be at right-angles to the urethra (Fig. 1). The portion of the muscle on the ventral side of the urethra is broad although relatively thin, but the portion situated dorsally to the urethra appears so voluminous on sagittal section that some doubt may arise as to whether the muscular fibres from the anterior upper portions actually end in the sides of the prostatic tissue. It seems more likely that they continue, at least in part, dorsally and distally towards the apex, entirely encircling the urethra and prostatic apex. A similar theory was advanced by ROLNICK & ARNHEIM. They explain the 'classical' description by the fact that normal sections made at right-angles to the plane of the urethra, do not run parallel with the direction of the sphincter fibres. A section, apparently as yet not made, corresponding to the direction of the latter in different areas should solve this important question. If the fibres of the external sphincter also run circularly in the upper inclining portion, they would also function as a true sphincter of the urethra and, on contraction, partly empty the distal portion of the prostatic urethra. The upper anterior fibres of the muscle are in intimate relation to the pubo-prostatic ligaments and are thus, to a certain extent, fixed to the symphysis. The external sphincter should therefore not only act as a sphincter for the urethra but also lift its diaphragmatic part as well as the apex of the prostate towards the symphysis. This view is corroborated by the results of our motility studies (Fig. 8 b and page 462). A similar lifting of the prostate occurs in total rupture of the urethra immediately above the diaphragm. In urethrograms the prostatic part of the urethra is then seen to be displaced upwards and forwards, a leakage of contrast medium occurring between the apex of the prostate and the pars diaphragmatica (Fig. 3). This elevation is effected by the contraction of the levator ani and probably also by the upper part of the external sphincter.

The upper portion of the external sphincter is directly connected to the lower portion which lies within the tendino-elastic lamellar system of the urogenital diaphragm. The bundles of muscle in this region lie in concentric layers round the urethra and are deformed distally by Cowper's glands which are encircled only by the more peripheral loops. The circular fibres form loops round the urethra alone, as well as round both the urethra and Cowper's glands. They are attached anteriorily to the transverse perineal ligament of Henle and neighbouring connective tissue; laterally they are attached to fasciae, as mentioned above, so that there is no direct insertion of the muscle to the bone (HOLL, CUNNINGHAM, and others).

The bulbo-urethral glands of Cowper are situated on the lower fascia of the diaphragm (the perineal membrane). Their size is less than that of peas but they show considerable variation in size, symmetry

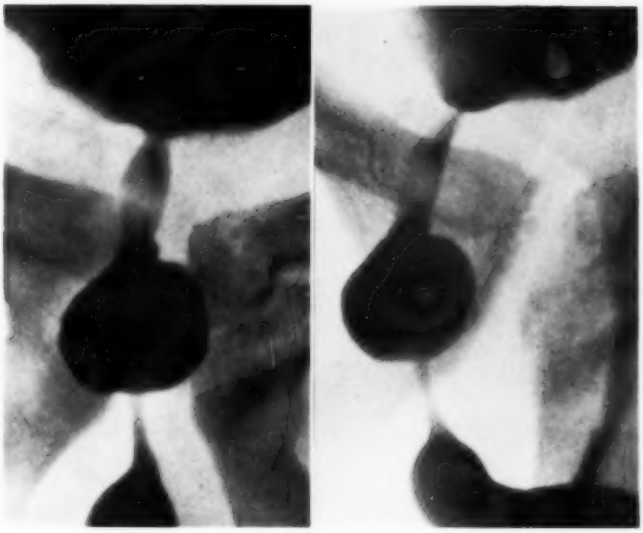
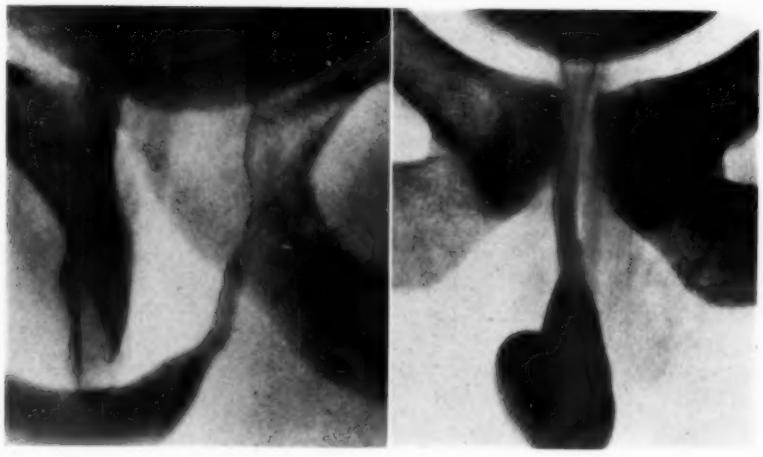


Fig. 3. Total urethral rupture at the junction between the prostatic and diaphragmatic parts of the urethra (some two weeks after trauma). A fracture of the symphysis, dislocated backwards, prevents the forward displacement of the apex of the prostate from being seen. (The clear patches in the contrast medium on the bladder floor caused by urine spurting from the ureters.)

and position. If enlarged, their position within the closed deep perineal pouch affects the course of the urethra. In unilateral *acute* Cowperitis we have found the urethra displaced slightly forwards and towards the opposite side in a gentle curve 'around the enlarged gland' (Fig. 4 a and b). In *chronic* Cowperitis, in which the gland is less enlarged but has undergone fibrous transformation, the course of the urethra is not affected in the same way; on the other hand the duct hardened by infection and consequently open, is not infrequently filled with contrast medium (Fig. 4 c).

The large number of descriptions of this area is accounted for by the fact that the musculature in the deep perineal pouch and perineum is subject to variations in occurrence, course, symmetry, and amount of connective tissue. Only the strongest muscles such as the external sphincter and bulbo-spongiosus muscles are constant, and even these are subject to variations in the amount of connective tissue which, according to GRIFFITH, is relative to sexual activity. In animal experiments, he has shown that the musculature of castrates is under-developed



a. b.

c.

Fig. 4. a—b. Deviation in the diaphragmatic part of the urethra in acute left Cowperitis. c. Contrast-filling of the left duct and Cowper's gland $1\,^1/_2$ years later in the same case; stricture at the junction of the pars nuda and the spongy part now present.

and mainly fibrous, whereas, during the rutting season it is strongly developed and rich in muscular elements. This should have some connection with the important genital function of this musculature. However, we have been unable to find any definite relationship between a short pars diaphragmatica and advanced age, decreased libido, estrogen treatment, castration, or the like. In our material, variations in length appear to be independent of these factors, but the thickness of the urogenital diaphragm (length of the diaphragmatic part of the urethra) varies considerably from case to case (see Fig. 10, long; Fig. 8, medium length; Figs. 7, 15 and 16, short). The position of the urogenital diaphragm and the pelvic organs is changed successively with age, from a

Fig. 5. Urethro-cavernous reflux from the posterior portion of the anterior urethra. The estimated postero-superior boundary of the bulb of the penis is marked by a dotted line. The pars nuda is projected free of the bulb.

high position in the pelvis in the new-born to a low position in the senile atrophy and tonus-turgor decrease of old age.

After the urethra has passed through the inferior fascia of the urogenital diaphragm (the perineal membrane), which forms the boundary between the posterior and anterior urethra, it enters the posterior part of the corpus spongiosum penis (Fig. 1) not, however, immediately, nor at right-angles to the surface, but by reason of its subpubic curvature, gradually and obliquely. The cavernous tissue then covers the urethra firstly at the back, then at the sides and finally at the front. It is, thus, only after some little distance that the urethra is wholly enclosed and the spongy part of the urethra commences. There is no musculature in the urethral wall in this region with the exception of the distally disappearing remains of the submucous, longitudinal, smooth muscle layer in the posterior urethra. This innermost part of the anterior urethra is, therefore, quite 'naked' on its ventral aspect and separated from the symphysis pubis only by the fatty areolar tissue. Dorsally, this naked portion is far shorter although distinct, as the cavernous tissue does not extend right up to the urethra as it passes through the perineal membrane (Fig. 1). In roentgenograms taken with 30°—40° rotation this dorsal wall appears more marked than it is in reality (Fig. 5), a fact which apparently escaped WESTERMARK when criticizing KNUTS-

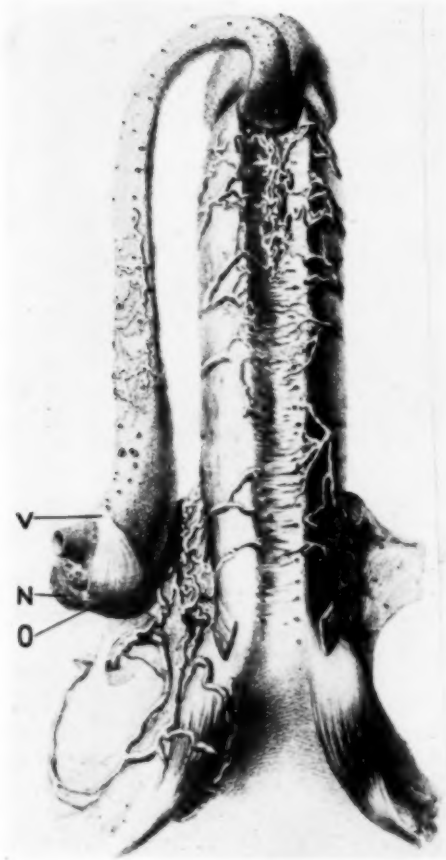


Fig. 6. The penis from below, with the spongy portion of the penis dissected free and excised at about the boundary between the anterior and posterior urethra. M. compressor hemisphericum bulbi seu m. compressor nudae marked *n* and *o* and its tendinous plate *v*. From KOBELT.

SON's delimitation of the anterior and posterior urethra in a similar view with cavernous reflux. WALDEYER called this part of the urethra pars praetrigonalis, indicating its position in front of (below) the urogenital diaphragm (trigonum). A number of later authors (including KAUFMANN and OPPENHEIM & LÖW) named it *pars nuda* as it has neither cavernous tissue nor musculature. We prefer this term which is short, expressive and unlikely to lead to confusion.

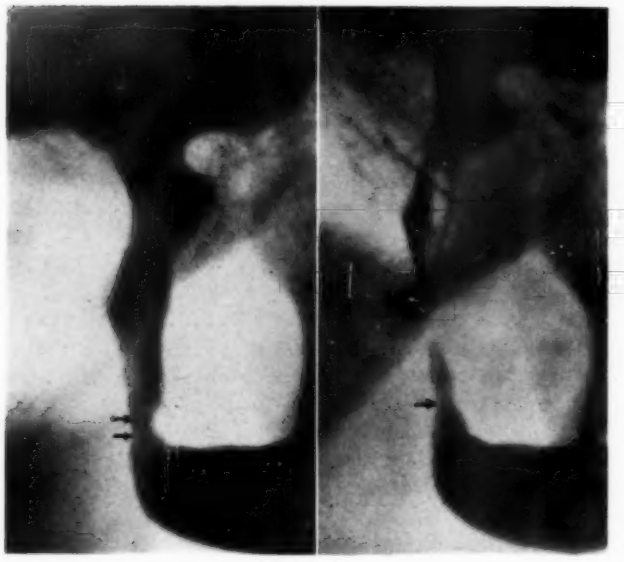
The *bulbo-spongiosus muscle* lies like a sheath round the posterior part of the spongy portion of the urethra and its most anterior portion (Houston's loop) encircles the whole penis. Anatomically the muscle is divided into several layers, but its nutrition, innervation and function are the same in its various parts.

KOBELT described (1844) a variable muscle deep below the bulbo-spongiosus muscle, situated directly on the cavernous tissue: *m. compressor hemisphericum bulbi* (Fig. 6). As its name indicates, this muscle covers the posterior portion of the bulb of the penis, which is here divided into two so-called hemispheres by a shallow, sagittal groove. The muscles of the two sides originate in the median line in this groove and run laterally and forwards covering the hemispheres with converging fibres which become increasingly tendinous. The tendons of the two sides meet in front of the urethra at the junction of the pars nuda and the spongy part, forming a tendinous plate some few millimetres in breadth. This lies immediately anteriorily to the urethra, with

no interposed cavernous tissue, from about 0.5 to 1.5 cm distal to the perineal membrane. The muscle is small, lies deep below the bulbo-spongiosus muscle and is very variable. This may account for the fact that since the beginning of the century, it has not, or but incompletely, been described in anatomy textbooks. It has sometimes been regarded as being but the deepest part of the bulbo-spongiosus muscle. However, according to KOBELT and HOLL, it has its own blood and nerve supply, distinct from that of the bulbo-spongiosus muscle; furthermore, it is separated from the latter by a layer of fascia-like connective tissue. It is, therefore, advisable to regard it as a separate muscle, with but a topographic connection with the bulbo-spongiosus muscle.

Function. It is our intention to discuss in detail the function of this musculature in a later paper; we shall now only summarize some points of importance in this connection. We base our views not only on a study of the literature but also on our own screening investigations and roentgenograms obtained during vaso-vesiculography and urethrography, with contraction of the pelvic floor and with 'straining down', during micturition and interrupted micturition.

Between the acts of micturition, when the bladder is relaxed, there is no need of any special sphincter to augment the pressure effected by the tonically contracted, smooth musculature of the prostate and the whole posterior urethra. In other words, the tonus of the external sphincter may remain low and the degree of contraction moderate. Simultaneously with an urgency to void, the tonus of the detrusor muscle of the bladder increases, the bladder 'rises' (EDLING), and this detrusor contraction leads to an active distention of the upper portion of the urethra. The contraction of the external sphincter is, at the same time, increased by reflex action. If, however, the external sphincter is voluntarily relaxed (together with the rest of the pelvic floor) the bladder and prostate sink, or are actively depressed by a short straining, and micturition starts. This sinking is, however, not essential for micturition, which may as well be effected with the lower urinary tract fixed to the walls of the pelvis in, for instance, overgrowing cancer of the prostate. If the external sphincter is caused to contract during micturition, for instance by a cough or by a conscious contraction ('holding back'), micturition is immediately interrupted. The lumen in the diaphragmatic part of the urethra is then closed; this is seen clearly on fluoroscopy. If this contraction is only momentary, the detrusor muscle does not relax and micturition continues immediately the sphincter contraction ceases. Should, on the other hand, the sphincter contraction be maintained by 'holding back' for a longer period, the detrusor contraction is gradually slackened, the urge to void disappears (which also occurs in connection with spontaneous urge to void when micturition



a. b.

Fig. 7. Contraction of the pelvic floor, the diaphragmatic part of the urethra being elongated and squeezed empty; its boundaries are marked by a stricture and an atrophic distention of the prostatic sulci respectively. (a) during injection; (b) during contraction. In (b) the medium under pressure in the anterior urethra has begun to re-enter the diaphragmatic part.

is inconvenient) and micturition does not start again spontaneously when the 'holding back' ceases.

On contraction of the pelvic floor the posterior urethra with the male adnexa and bladder floor are raised one or more centimetres in the pelvis. This is effected mainly by the levator muscles but probably also partly by the external sphincter, by reason of the forward movement, most marked at the apical area of the prostate, whereas the internal orifice of the urethra is raised more directly upwards. In 'straining down' and micturition, the organs sink almost the same distance below their normal positions at rest; this movement is also combined with a relative forward displacement of the apex of the prostate. The distance between the highest and lowest positions may sometimes amount to several centimetres. In contraction the diaphragmatic part of the urethra is squeezed empty and lengthened (Fig. 7), and in 'straining down' it decreases somewhat in length, seemingly forced back into itself. This is made possible by the external sphincter in the deep perineal

pouch with its elastic attachment to the pelvic walls, allowing a not inconsiderable 'sliding'. This appears to be necessary for the maintenance of sphincter function in these wide variations of position, and would seem to be impossible if the muscles were attached directly to the skeletal parts.

These studies of the pelvic floor function by means of screening and roentgenography during injection and after 'holding back', 'straining down', et cetera, show undoubtedly that the interruption of micturition is effected primarily by voluntary contraction in the external sphincter region. The view put forward by MUELLNER that it is effected by the smooth musculature in the bladder neck, appears incorrect. This is also indicated by the fact that, after both transurethral prostatic resection and transvesical prostatectomy, the bladder neck is often seen to be wide open and filled with contrast medium right down to the seminal collicle without continence being affected (and without the presence of micturition urgency). However, if in addition the external sphincter area is damaged, by, for instance, transurethral operation, incontinence may occur even if no resection of the external sphincter musculature has taken place. The risk in this connection is greater if damage to the posterior rather than to the anterior wall is sustained (ROLNICK & ARNHEIM). This is probably due to the fact that the closing of the diaphragmatic part of the urethra is effected mainly by its posterior wall being lifted forwards and upwards. This mechanism is more easily disturbed by scarring of the posterior than of the anterior wall.

The function of the muscles round the anterior urethra is greatly dependent on the condition of the cavernous tissue, a fact which is not usually given enough attention. In erection the cavernous tissue is hard and offers firm support to the muscles which may, therefore, on contraction, quickly and wholly compress and empty the urethra — as in seminal ejaculation. However, the cavernous tissue is usually soft and sponge-like, and the contractions of the surrounding muscles are intercepted and deadened. They then have considerably less effect on the lumen of the urethra and more on the blood-filling of the cavernous tissue (DELBET). After completed micturition the bulbo-spongiosus muscle does, however, empty the remaining urine from the posterior parts of the anterior urethra, thanks to the lack of resistance in the rest of a normal anterior urethra. If, on the other hand, the anterior urethra is filled with contrast medium under pressure (between the external sphincter and the injection instrumentarium), the bulbo-spongiosus muscle has no noteworthy effect on the appearance of the lumen.

This argument is, however, only to a lesser degree applicable to the m. compressor hemisphericum bulbi as its tendinous plate is anteriorly in contact with the urethra, without any interposing cavernous tissue.

On contraction it pulls the anterior wall of the urethra backwards, so that the lumen is in part or wholly compressed. The lateral walls are also pressed somewhat inwards, whereas the posterior wall is not, or only slightly, affected — there is a great deal of intervening deadening cavernous tissue in this location (Figs. 1 and 8). KOBELT's name 'm. compressor hemisphericum bulbi' refers to the compressive effect of the muscle on the cavernous tissue, but disregards its effect on the urethral lumen in the pars nuda. Its effect on the pars nuda appeared so important in our functional urethrographic studies that we suggest the term be replaced by *m. compressor nudae* (*et hemisphericum bulbi*).

The roentgen appearance of m. compressor nudae. The pars nuda and m. compressor nudae seemed to have been forgotten during the period between the wars, just at the time of the keenest discussion of roentgen examinations of the urethra in the literature. Discussion of the roentgenologic demarcation of the anterior and posterior urethra, for the most part based on the erroneous supposition that the anterior urethra was entirely lacking in musculature, was consequently led astray (CHEVASSU, GUICHARD & DUVERGEY, HEITZ-BOYER, OLTRAMARE & MARTINET, WESTERMARK and others).

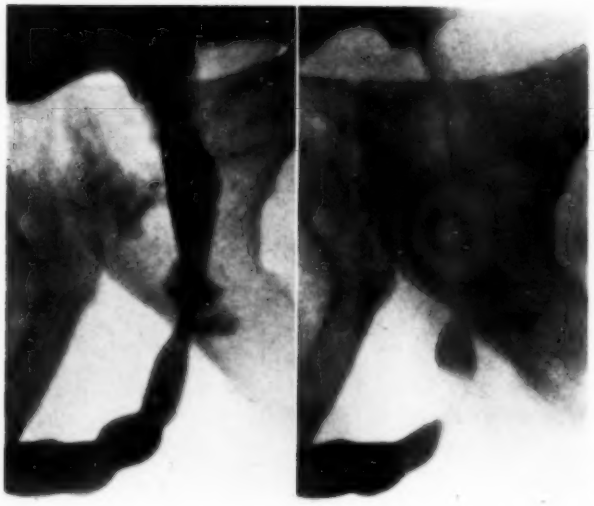
HORTOLMEI & KATZ-GALATZI mention 'pars nudica' as the region where the anterior urethra continues up into the pars membranacea. No musculature is named, but a film (their Fig. 10) shows an indentation in the lumen of the urethra at the level of the m. compressor nudae. This is described as '*une forme d'un clochet*' without further explanation.

When using a high-viscosity contrast medium and the urethrographic technique described in our earlier paper (injection during relaxation, followed by active contraction of the pelvic floor), the effect of contraction of both the external sphincter and a possible m. compressor nudae may be studied. The roentgen appearances of a contracted m. compressor nudae correspond well, in the majority of cases, with the anatomic description quoted above (Fig. 8). The tendinous plate of the muscle draws in the anterior wall of the urethra at the boundary between the pars nuda and the spongy portion, about a centimetre below the bulbo-membranous junction. The remaining portion of the pars nuda — between the m. compressor nudae and the external sphincter — is practically unchanged, as compared with the injection picture. It may, however, increase in volume, indicating that its wall is soft, thin and yielding and offering but little resistance to the increased intra-urethral pressure (Fig. 8 b and d).

It becomes evident that there are considerable variations as regards the presence and extent of the m. compressor nudae. There is no definite figure for the frequency of this variable muscle in the literature. HEITZ-BOYER claimed that the lumen in the pars diaphragmatica was wider

Fig. 8. Contraction of the m. compressor nudae. Left: during injection; right: during pelvic floor contraction; above: oblique views; below: a. p. views.

and bounded proximally and distally by crescent-shaped folds which constricted it (a fact we could not verify either in films or by means of endoscopic examination). On the basis of this statement CHEVASSU studied 1,400 urethrograms (probably only injection films obtained with iodized oils) and in approximately one case in twenty found an impression in the anterior wall of the urethra at the boundary between the anterior and posterior urethra. CHEVASSU, like HEITZ-BOYER, believes this indentation to be due to the fact that the urethra, in



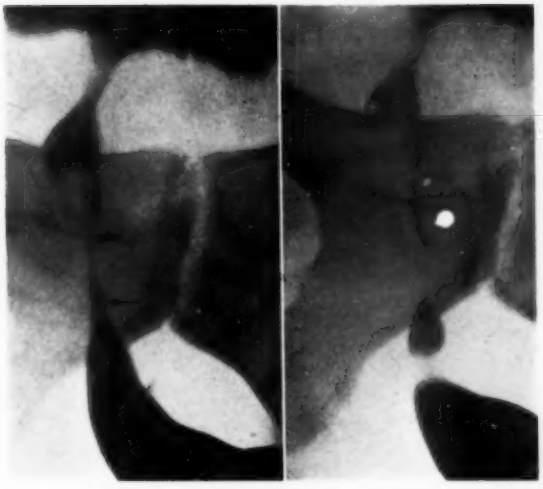
a. b.

Fig. 9. Valvular stricture at the position of the broad impression. (a) during injection: (b) during contraction.

passing through the perineal membrane, does not widen as much as the muscle-encircled portion of the diaphragmatic urethra. This impression, caused by '*aponévrose moyenne*', should therefore, be the boundary between the anterior and posterior urethra. Judging from the films published however, the impressions are, in all probability, caused by a contracted m. compressor nudae.

In our material, as previously reported, 12 cases out of 66 (18 per cent) show a clear indentation in the contour of the anterior urethra and which can only be accounted for by a contraction of the m. compressor nudae. In 13 cases (20 per cent), a contraction exists but is not so marked; in these cases the presence of this muscle is probable. In 32 cases (48 per cent) no such contraction can be seen. In the remaining 9 cases (14 per cent) the whole pars nuda and the diaphragmatic part were emptied of contrast medium on contraction (see further below). According to these calculations, the m. compressor nudae occurs in this material in approximately every other case; it is, therefore, not rare.

The type of the remaining portion of the pars nuda and the length of the indentation caused by the m. compressor nudae may vary. Different types of pars nuda and m. compressor nudae are shown in Figs. 8—14. Anatomists give no definite figure for the length of its tendinous plate. According to the attached figures it may vary from a few milli-

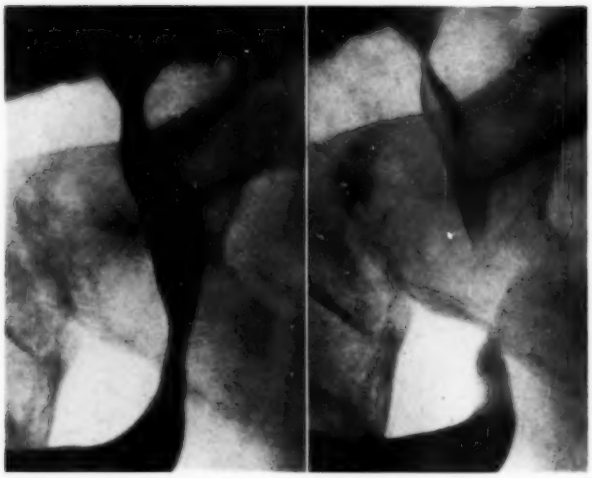


a. b.

Fig. 10. Long diaphragmatic part. (a) during injection; (b) during contraction.

metres (as in Fig. 14 b) to over a centimetre (Fig. 9 b). If the m. compressor nudae is not present, the upper part of the anterior urethra in the contraction films ends in the form of a pointed cone, constituted by the pars nuda. If, in a contraction film, the contrast medium in the urethra has vanished from the region of the prostatic apex as far down as the lower part of the subpubic curvature, it implies that the lumen has been compressed not only in the diaphragmatic part but also in the pars nuda. There is no musculature apart from the variable m. compressor nudae in this region to affect the urethral lumen. According to OPPENHEIM & LÖW, and others, certain apes (*e.g.* baboon, papio (cynocephalus) hamadryas) have a strongly developed m. compressor but lack a pars nuda in the true, limited sense of the word, *i.e.* the m. compressor nudae extends right up to the external sphincter. In all probability this muscle, when fully developed, may in man too, wholly embrace the pars nuda and on contraction empty the entire pars nuda of contrast medium. The pars nuda in nine cases in our material was, as mentioned above, completely emptied on contraction, indicating a maximal development of the m. compressor nudae (Fig. 13 b).

We have not observed any valve-shaped, stricture-like impression in the anterior wall of the urethral lumen, due to a minimal extension of the tendinous plate of the m. compressor nudae.



a. b.

Fig. 11. The diaphragmatic urethra, medium length. (a) during injection; (b) during contraction.

The roentgenologic differential diagnosis between a stricture and a contracted m. compressor nudae may at times be somewhat difficult. A stricture is seen most clearly in injection films when the lumen is distended as much as possible. A chance contraction of the m. compressor nudae may produce an impression in the urethral wall simulating a non-encircling stricture, especially in connection with an irritative contrast medium (too cold or too warm) or insufficient anaesthesia. This contraction, however, is most often broad and always localised to the anterior wall of the urethra at the junction of the spongy part. If the roentgenographic examination is performed with careful anaesthesia of the mucous membrane, and with a non-irritative contrast medium, spasm in the m. compressor nudae does not usually occur. In the contraction film — obtained while the patient contracts the pelvic floor musculature — the effect of the m. compressor nudae on the lumen is seen, as opposed to the injection film in which the lumen is uniformly distended. The different projections show the position mainly on the anterior aspect of the urethra. If an indentation is seen in both the injection and contraction films, or if accentuated in the contraction film, it is caused by a m. compressor nudae plus a stricture (Figs. 9, 14 and 15). If the impression can be seen clearly to run right round the urethral lumen, it is with certainty a stricture; the m. compressor nudae affects the front and sides of the urethral lumen to a certain extent, but not the

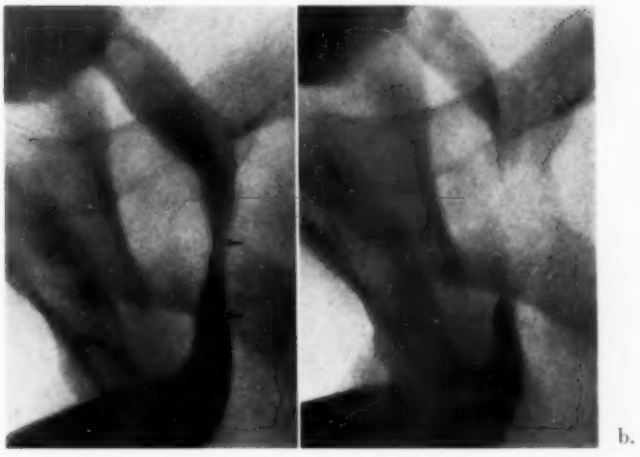


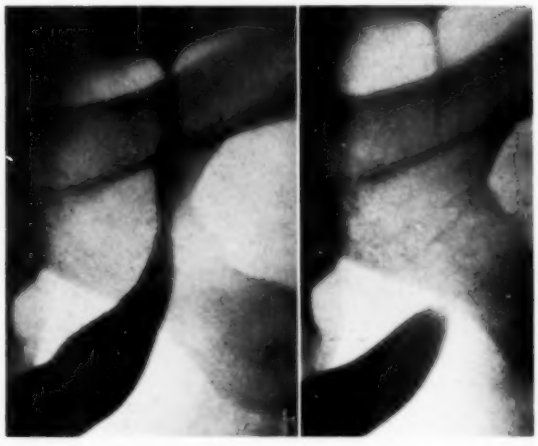
Fig. 12. The diaphragmatic urethra, unusually long. (a) during injection; (b) during contraction.

back (due to interposing cavernous tissue). Motility studies may then, as a rule, enable a differential diagnosis to be made.

The boundaries of the pars diaphragmatica urethrae. In determining the size of the prostate, the position of valves and strictures, et cetera, it is of importance to be able to establish the boundaries of the diaphragmatic part of the urethra. According to several authors, including NESBIT and BARNES & MARTIN, this may be achieved by endoscopy. The diaphragmatic urethra is a relatively immobile structure, whereas the adjoining prostatic urethra is slightly mobile. When the prostate gland is moved, 'the surface configuration at the prostato-membranous junction is altered by wrinkling in a manner comparable to that of the accordion-like wrinkling of the bellows that connects two Pullman cars', due to the loose connections between the mucous membrane and the underlying tissue. Distally, the bulbo-membranous junction is the point at which the external sphincter compresses the lumen and stops the inflowing fluid from entering the bladder.

Roentgenologic delimitation has, according to the literature, caused great difficulty. It is primarily the distal boundary which is still regarded as almost impossible to localise exactly (GUICHARD & DUVERGEY). As we have pointed out above, no exact measurements can be given as regards the pars diaphragmatica. Its two boundaries must be determined in each individual case.

The infracollicular part of the prostatic urethra lies proximally. From the standpoint of roentgen anatomy this differs from the dia-



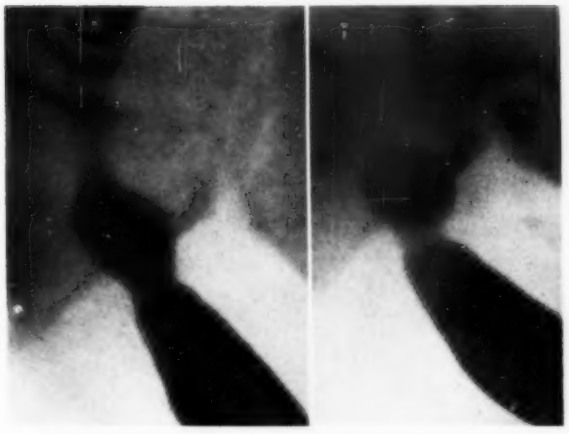
a. b.

Fig. 13. The entire pars nuda emptied of medium, probably by a m. compressor nudae of maximal development, extending right up to the external sphincter. (a) during injection; (b) during contraction.

phragmatic part in that its lumen is wider and prostatic sulci are present on each side of the often strongly developed urethral crest. Their demonstration, however, demands a well-distended lumen. Very broad sulci (in so-called atrophy of the prostate) often end in projections directed downwards towards the diaphragm (Figs. 16 and 17). This boundary may, therefore, often be localised already in the injection film. In roentgenograms obtained during contraction of the pelvic floor and the external sphincter, this boundary is more easily seen; the diaphragmatic part is completely emptied of contrast medium by the contraction, whereas the medium in the prostatic part of the urethra does not wholly disappear. The prostato-membranous junction then becomes the point at which, in the contraction film, the contrast medium in the posterior urethra is held up distally (Figs. 11 b, 12 b and others).

The distal boundary of the diaphragmatic part of the urethra may also as a rule be established roentgenographically, but its representation varies with the technique used. Exposures made during injection of the contrast medium with a relaxed pelvic floor, after injection with a contracted external sphincter together with a relaxed pelvic floor, and during micturition, produce films which vary considerably in appearance.

In urethrography carried out in the cadaver, the lumen is of uniform width, with no 'isthmus' (BRONNER). The external sphincter is completely relaxed.



a. b.

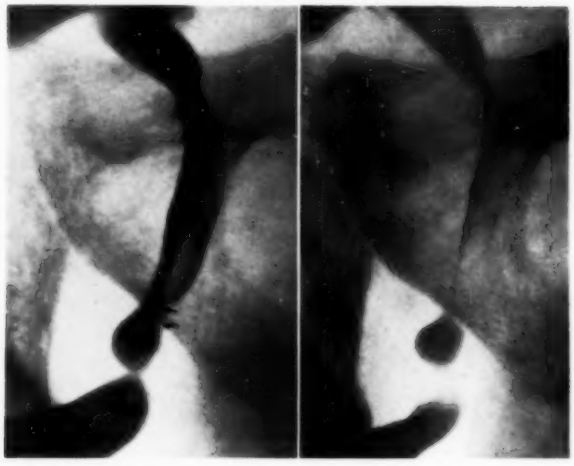
Fig. 14. Stricture at the position of the tendinous plate of the m. compressor nudae. The tendinous plate is in this case short. (a) during injection; (b) during contraction.

In a normal injection film in which the sphincter tonus is slight, the narrowest portion of the lumen will be seen immediately below the prostatic apex at the middle of the diaphragmatic part of the urethra. Exact determination of the bulbo-membranous junction in this type of film is impossible, as the urethra broadens successively downwards and the boundary lies some distance below on this cone-shaped region.

If contrast medium is injected towards a strongly contracted sphincter its entry into the posterior urethra is barred; the pars diaphragmatica is completely empty. The prostatic urethra and the adnexal organs are lifted (some centimetres) by the pelvic floor contraction. This lengthens the diaphragmatic part of the urethra, and the mucous membrane is probably taken up from the pars nuda. The pars nuda takes on the shape of a moderately short cone with its apex at the lower edge of the sphincter, *i.e.* the perineal membrane.

If the pressure in the anterior urethra is not high, the pelvic floor not contracted and the external sphincter only moderately tonically contracted, the pars nuda cone will become elongated, although its apex will still lie at the lower edge of the closed sphincter at the level of the perineal membrane. The 'conical peak' is, however, not projected at the same point in the pelvic skeleton in these two films, due to its change in position during contraction.

Finally, in the micturition film it is possible to determine the boundary between the anterior and posterior urethra in only occasional cases.



a. b.

Fig. 15. Stricture at the position of the indentation of the m. compressor nudae. Pathologically distended prostatic urethra. Short diaphragmatic urethra. (a) during injection; (b) during contraction.

On micturition, the pelvic floor is relaxed and the prostate and bladder floor are depressed and displaced slightly dorsally (cf. previously). This displacement is sometimes very marked and angles may then be formed at the extremities of the more perpendicular diaphragmatic part of the urethra (superiorily with the inclined prostatic part and inferiorily with the more horizontal anterior portion). The upper angle will be directed backwards and downwards, the lower angle forwards and upwards. These angles permit of a demarcation of the pars diaphragmatica. If, on the other hand, the patient be instructed to interrupt micturition and a film obtained at the exact moment of such interruption, the external sphincter will be seen clearly. If a m. compressor nudae be present, its co-contraction may define the pars nuda from the spongy part of the urethra.

If the anterior urethra is described as starting at the inferior fascia of the urogenital diaphragm (the perineal membrane), the statement that the wall of the anterior urethra is wholly lacking in musculature is not correct; this is by reason of the varying presence of m. compressor nudae and explains the keen discussion as to the position of this important boundary. In Sweden the problem has been treated by KNUTSSON and WESTERMARK. KNUTSSON, in his thesis (1935), considered the proximally cone-shaped, pointed ending ('the cone') to belong to the anterior

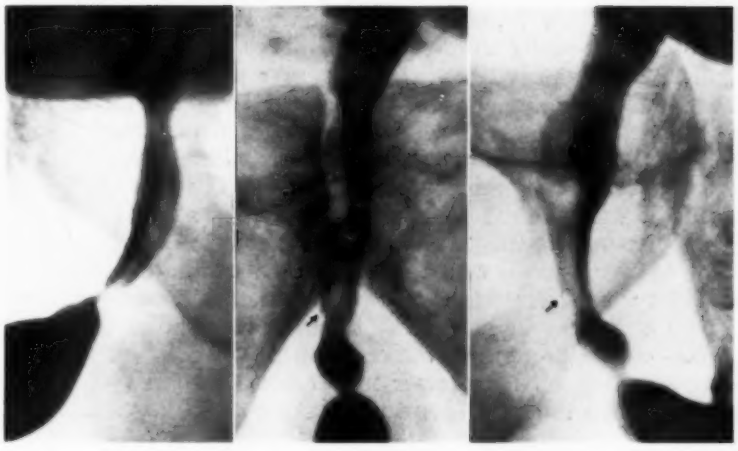


Fig. 16. Fig. 17 a. 17 b.

Fig. 16. Sulci of the wide prostatic urethra projecting against the narrow diaphragmatic part.

Fig. 17. The right prostatic sulcus so distended as to form a projection against the urogenital diaphragm. In addition a stricture at the boundary between the pars nuda and the spongy portion. (Same case as in Fig. 15). (a) a. p. view; (b) oblique view; both during injection.

urethra. WESTERMARK (1937) claimed that it belonged to the posterior urethra, and attempted to prove his point in studies of films exposed during and after injection, both with a relaxed and contracted pelvic floor (and with the contrast fluid being cooled). He believed the boundary to lie at the point of the most distal impression caused by muscular contraction; in other words the point at which, during contraction of the pelvic floor, an impression appeared in the anterior wall of the cone-shaped portion of the urethra. Bearing the m. compressor nudae in mind, the cause of this impression is explained. The cone above it corresponds to the pars nuda. The 'conical peak' is on a level with the perineal membrane and marks the boundary between the anterior and posterior urethra, whereas the diaphragmatic part of the urethra contains no contrast medium. The employment of cool contrast fluid caused the m. compressor nudae to contract so strongly that the lumen was fully compressed and the contrast medium failed to fill even the pars nuda.

Knowledge of the pars nuda and the presence of the m. compressor nudae is not only of interest from a roentgen anatomy standpoint, but may also be of certain *clinical* importance. One of the situations for

which strictures show a predilection is the posterior portion of the anterior urethra, especially the region of the pars nuda (WILDBOLZ) (Figs. 4 c, 5, 7, 9, 14, 15, 16 and 17). There are several reasons why traumatic and inflammatory lesions occur in this part of the urethra. The pars nuda is very mobile, yet at the same time 'naked' and unprotected, and lies between the fixed diaphragmatic and the mobile anterior parts of the urethra. A blow on the perineum easily damages the pars nuda. If, when introducing an instrument into the urethra, the handle is lowered too soon, its point will touch the pars nuda; if lowered too late, the point will come too far dorsally towards the perineal membrane and the pars nuda will be excessively stretched. In both cases the mucous membrane of the pars nuda may be injured. In the event of insufficient anaesthesia and relaxation, the presence of the m. compressor nudae will increase this risk. A contracted m. compressor may catch (or 'brake') the point of the instrument so that the operator is misled as to its situation.

SUMMARY

The authors present a detailed anatomic description of the urogenital diaphragm and the striated musculature at the boundary between the anterior and posterior urethra based on roentgen films and discuss the function of the muscles. The posterior part of the pars anterior — pars nuda — differs from the remainder of the anterior urethra in not being surrounded by cavernous tissue. A 're-discovered' muscle, by the authors named m. compressor nudae (m. compressor hemisphericum bulbi, KOBELT), dividing the pars nuda from the spongy part of the anterior urethra is described and the presence of, and variations in this muscle discussed. The differential diagnosis between strictures in the pars nuda and contractions of the m. compressor nudae is illustrated. The authors discuss the roentgenologic appearances of the diaphragmatic part of the urethra under different circumstances both as regards its position and, above all, its boundaries. These conditions are not only of roentgenologic importance, but may also be of clinical significance.

ZUSAMMENFASSUNG

Die Verfasser geben eine detaillierte anatomische Beschreibung des Diaphragma urogenitalis und der quergestrieften Muskulatur an der Grenze zwischen vorderer und hinterer Urethra unter Berücksichtigung des Röntgenbildes dieser Gebiete. Die Funktion dieser Muskulatur wird beschrieben. Es wird hervorgehoben, dass der innere Teil der Pars anterior — Pars nuda — sich von den übrigen Abschnitten der vorderen Urethra dadurch unterscheidet, dass die Urethra hier nicht von kavernösem Gewebe umgeben ist. Ein „wieder entdeckter" Muskel, von den Verf. M. compressor nudae benannt (M. compressor hemisphericum bulbi, KOBELT), der diese Pars nuda von der Pars cavernosa abgrenzt, wird eingehend beschrieben. Das Vorkommen und die Variationen dieses Muskels werden untersucht und die Differentialdiagnose zwischen Strikturen in der Pars nuda und Kontraktionen des M. compressor nudae wird illustriert. Das Röntgenbild der Pars diaphragmatica unter verschiedenen Bedingungen wird besprochen, sowohl bezüglich des Aussehens und der Lokalisation sowie vor allem der Begrenzung. Schliesslich wird hervorgehoben, dass diese Umstände nicht nur röntgenologisch wichtig sind, sondern dass sie auch eine gewisse klinische Bedeutung haben können.

RÉSUMÉ

Les auteurs présentent, du point de vue radiologique, une description anatomique détaillée du diaphragme uro-génital et de la musculature striée à la limite de l'urètre antérieur et postérieur. Ils étudient la fonction de ces muscles. La partie tout à fait postérieure de l'urètre antérieur — pars nuda — diffère du reste de l'urètre antérieur en ce qu'elle n'est pas entourée de tissu caverneux. Un muscle séparant la pars nuda de la partie spongieuse de l'urètre antérieur a été 'redécouvert' — m. compressor hemisphericum bulbi de KOBELT — nommé par les auteurs m. compressor nudae; ils le décrivent et étudient sa fréquence et ses variations. Le diagnostic différentiel entre les rétrécissements de la pars nuda et les contractions du m. compressor nudae est illustré. Les auteurs étudient les aspects radiologiques de la partie diaphragmatique de l'urètre dans diverses circonstances, sa localisation et surtout ses limites. Ces conditions n'ont pas seulement une importance radiologique mais peuvent aussi avoir une signification clinique.

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FROM THE RADIOISOTOPE LABORATORY OF RADIUMHEMMET, STOCKHOLM, SWEDEN

A STUDY OF THE IODINE-CONCENTRATING FUNCTION OF THE THYROID AFTER TREATMENT WITH RADIOACTIVE IODINE

by

Lars-Gunnar Larsson and *Inger Ragnhult*

When a hyperthyroid patient is treated with radioactive iodine (I^{131}) the result desired is a subtotal destruction of the thyroid tissue sufficient to remove the hyperthyroid signs without causing definite hypothyroidism. The irradiation dose delivered to the thyroid tissue after an orally administered dose of I^{131} depends upon several factors: the distribution of the isotope in the gland, the thyroid volume, the magnitude of the uptake and the effective half-life of I^{131} in the thyroid. In cases with diffuse goiter a theoretical average irradiation dose may be calculated from the last three factors. It must be emphasized, however, that the estimation of these factors presents considerable errors, and the calculated irradiation dose gives only a rough idea of the real irradiation dose. Another difficulty in the choice of a suitable oral dose is the varied response of the thyroid to irradiation in different individuals. It is for instance the experience from the field of roentgen therapy that a diffuse toxic goiter in a young patient is more radiosensitive than a toxic adenomatous goiter in an old subject, and it is also an old observation that hyperfunctioning thyroid tissue is more radiosensitive than normal thyroid tissue.

Despite the difficulty to control these factors in the choice of the dose administered, good results have been obtained with I^{131} treatment by the "single dose technique". This fact indicates the existence of a fairly good margin between the irradiation dose, which causes sufficient subtotal destruction of the thyroid, and the dose which causes complete destruction. Another factor of importance is probably the regeneration of thyroid function after treatment. Some authors have described tran-

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sitory hypothyroidism in patients treated with I^{131} (3, 4, 6, 7) indicating a regeneration after the initial depression of function. We have not, however, been able to find any systematic investigations on this subject.

Since 1950 selected cases of thyrotoxicosis have been treated at Radiumhemmet with I^{131}. Since the same time, a group of euthyroid patients with severe cardiac failure have been treated with I^{131} in order to produce hypothyroidism (cf. 2). In these materials, tracer studies with I^{131} were performed before and about 3 and 6 months after a single therapeutic dose of radioactive iodine.

Material and Methods

The thyrotoxic group consisted of 23 cases and the euthyroid group of 10 cases. The first tracer test after the treatment was performed after about 2—4 months and the second after about 5—9 months. Only cases receiving a single therapeutic dose during this period are included in the material.

The therapeutic dose of I^{131} administered to thyrotoxic patients was based essentially on the clinical estimation of the thyroid volume and the measured 24 hours uptake in the thyroid after the preceding tracer dose. We have not tried to express the delivered dose in rep or in microcurie/g tissue, as we have the impression that these figures give an illusory indication of the exactness of the method. In cases with a pathologically increased thyroid uptake of I^{131} we used the following rough dosage scheme: cases with a probably small thyroid volume (for instance operated cases without palpable goiter) 3—5 mC, cases with a normal or slightly enlarged thyroid volume 5—7 mC, cases with a moderately enlarged thyroid 7—10 mC and cases with a large goiter 10—15 mC. The euthyroid patients had no clinical or roentgenological signs of goiter and received 6—8 mC I^{131}. The doses were given by mouth. The radioactive iodine was delivered from Harwell and used within one week. No carrier iodine was added. The amount of inactive iodine contained as impurity in the solution of I^{131} delivered from Harwell is less than 5 microgram/mC in the fresh solutions. These amounts of inactive iodine do not *per se* influence a subsequent tracer test (5). No iodine treatment was given before or after the radioiodine treatment. A few patients were previously treated with thiouracil and this substance was withheld at least 3 days before the preceding tracer test. No thyroid medication was given during the observation period.

The tracer tests with I^{131} performed before and after the treatment included simple estimation of 24 hours uptake in the thyroid and 24 hours urinary excretion after an orally administered tracer dose of 50—100 microcurie carrier-free I^{131}. The uptake was measured with a lead-shielded gamma-sensitive Geiger-Müller tube situated 25 cm from the skin of the neck and filtered with 2 mm lead. *In vivo* estimations of the thyroid uptake produce considerable errors. If repeated investigations in the same subject are compared, however, these errors are predominantly constant providing that identical geometrical conditions are used. When the tracer test was performed within 3 months after the therapeutic dose any residual activity in the thyroid was measured prior to the administration of the tracer dose. In a few cases residual activity was found and in these cases a correction of the uptake made after the tracer dose was measured. The urinary excretion of I^{131} was measured with a gamma method.

In a few cases more complicated tracer investigations were performed including the estimation of thyroid clearance, serum protein-bound I^{131} after 2 days and biological half-life of I^{131} in the thyroid. This series is still incomplete and the results are not reported here.

Results

The hyperthyroid group. The reported material which is graphically illustrated in diagram 1, showed the following characteristics.

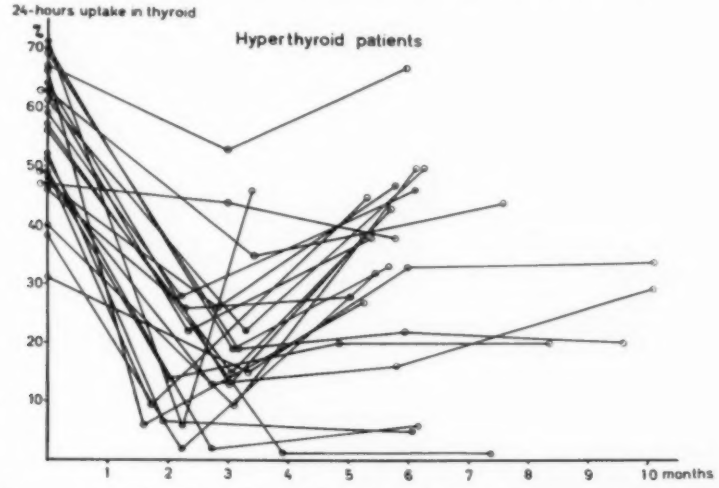

Diagram 1. Thyroid uptake of I^{131} in 23 thyrotoxic patients before and at different times after a single therapeutic dose of radioactive iodine.

1. Three cases with very low thyroid uptake of I^{131} (2—7 %) after 2—4 months had also very low uptake (2—6 %) after 6—8 months. They had clinically definite myxoedema.

2. In the remaining cases, with one exception, the thyroid uptake after 5—8 months was evidently higher than the uptake after 2—4 months but in most cases still below the level before treatment. Five patients had a very low uptake (2—9 %) after about 2—3 months but nevertheless the function regenerated and no definite hypothyroidism developed. The mean value of the 24 hours thyroid uptake was before treatment 55.0 %, after 2—4 months 17.4 % and after 5—8 months 33.7 %.

3. Transitory hypothyroidism was noted in some patients with low thyroid uptake after 2—4 months.

4. Some patients, which were improved after about 3 months, had again increased symptoms after about 6 months and required further treatment.

5. In four patients, a third tracer test was performed about 8—10

months after treatment. In three of these cases this test gave about the same result as the second tracer test.

The euthyroid group. This group consisted of patients with severe cardiac failure. Most of the patients had oedema and other signs of decompensation. In such cases the simple tracer test, including estimation of 24 hours thyroid uptake and urinary excretion, is a functional test with especial errors due to the diffusion of I^{131} into the oedema, which causes a retardation both of the uptake in the thyroid and the urinary excretion (1). The best test for investigation of the iodine concentrating function of the thyroid in such cases is the determination of thyroid clearance. If the differences are high, however, some conclusions may be justified even from the simpler tracer tests. (Diagram 2.)

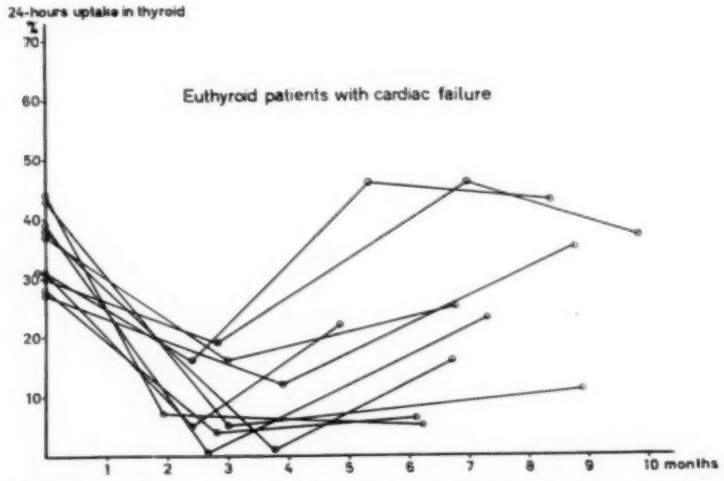

Diagram 2. Thyroid uptake of I^{131} in 10 euthyroid patients with cardiac failure before and at different times after a single therapeutic dose.

1. Three cases with very low uptake (4—7 %) after 2—3 months had also very low uptake (6—13 %) after 6—9 months and had pronounced hypothyroidism.

2. In the remaining cases the uptake after 5—7 months was definitely higher than after 2—4 months, indicating a regeneration of the iodine concentrating function. The mean value of the 24 hours uptake before the treatment was 34.8 %, after 2—4 months 8.8 % and after 5—9 months 23.4 %. The depression of the uptake after 5—9 months compared with the uptake before the treatment was, in the individual cases,

however, not so evident as in the thyrotoxic group. This may be due to the test being less reliable in patients with cardiac decompensation. Three cases had very low uptake (0—5 %) after 2—4 months although the function regenerated and these cases developed only slight definite signs of hypothyroidism.

3. In two patients a third tracer test was performed 8—10 months after treatment and gave approximately the same result as the test performed after 5—7 months.

Discussion

Radioiodine treatment in these cases was given in order to produce subtotal destruction of the thyroid tissue. The iodine concentrating capacity of the thyroid was followed by repeated tracer tests, which illustrated that after the initial depression a regeneration of the function occurred in most cases. It seems probable that the function was at a minimum at some time within the first three months after the treatment and regenerated during the following months. In some cases, in which the destruction of the thyroid tissue probably was very pronounced, no appreciable regeneration of the function occurred and these patients had definite myxoedema.

The nature of this regeneration is not known. It may be a real cellular regeneration, it may be an increased function of over-living cells or it may be a recovery of thyroid cells with temporary inhibited function during the irradiation reaction. These problems can only be solved by detailed experimental studies, including comparative histologic and physiologic investigations.

Knowledge concerning the depression and later regeneration of thyroid function after radioiodine treatment is valuable for the practical management of thyrotoxic patients. Of patients with very low iodine concentrating function after about 3 months, some will have definite myxoedema while in some cases regeneration of the function occurs. It is advisable to control these patients carefully. If signs of regeneration occur, no substitution therapy should be instituted, but if progressive signs of severe hypothyroidism appear, medication should be given before clinically complete myxoedema has developed. Patients with pathologically increased function after about 3 months have usually also increased function after about 6 months. If a patient still has thyrotoxic symptoms and increased thyroid uptake of I^{131} after about 3 months, a second therapeutic dose as a rule is indicated. In patients with normal uptake after 3 months, there is little risk of hypothyroidism. Some of the patients, however, especially those with an uptake in the upper limit of the normal range, again have thyrotoxic symptoms and an increased

uptake after about 6 months and require more treatment. After 6 months from the last therapeutic dose the functional level seems to be rather stable, and cases which later on receive hyperthyroid symptoms may, from the practical point of view, be regarded as real recurrences. Reported treatment results, based on an observation time shorter than 6 months after the last therapeutic dose, have very little value; the initial depression of the thyroid function after the treatment may produce a temporary improvement of a patient not definitely cured.

It is possible that in the future more exact dosage technique, including determination of effective half-life, more reliable uptake measurements with correction of errors due to distance and absorption, and estimation of the thyroid volume with collimated scintillation counters will give still better results than at present. It will never be possible, however, to alight on a method which will cure all the patients by a single therapeutic dose without causing any a certain number of cases of hypothyroidism. It also seems probable that in the future knowledge concerning the depression and regeneration of thyroid function after treatment will be of essential value for the management of these cases.

It is of course not our opinion that the simple estimation of the 24 hours thyroid uptake and urinary excretion of I^{131} gives the whole truth about the thyroid function. The test has a considerable number of errors, and even if it gave a true picture of the iodine concentrating function, this would be only one side of the thyroid function. The thyroid cells have schematically three functions: (1) to concentrate inorganic iodine from the blood, (2) to synthesize the iodine-containing hormone and (3) to release the hormone into the blood. These functions may be damaged in different degrees by irradiation treatment and there are in fact some observations which favour this opinion. We noted for instance several thyrotoxic patients clinically improved 2—3 months after the treatment but with the same pathological uptake of I^{131} in the thyroid as before treatment. These findings indicate that the hormone-producing capacity of thyroid tissue may be damaged to a higher degree by irradiation than the iodine concentrating capacity. Further information on this subject may be gained by performing concomitant functional tests including the estimation of the basal metabolism, blood cholesterol, plasma protein-bound iodine, thyroid clearance, plasma protein-bound I^{131} and biological half-life of I^{131} in the thyroid. Such investigations would be of considerable theoretical interest. We have the impression, however, that for the practical management of these cases the clinical examination and simple tracer studies with I^{131} are quite sufficient. As for the primary diagnosis of thyrotoxicosis, the clinical picture is more important than any laboratory investigations. Especially during the first months after

treatment, however, the tracer test may give valuable information not to be gained from the clinical examination alone.

Acknowledgments

We wish to acknowledge our indebtedness to the colleagues who selected and managed the clinical control of the patients. The euthyroid patients with cardiac failure and some of the thyrotoxic patients were selected for treatment at the Medical Clinic IV, St. Erik's Hospital by Dr. R. Frisk. Most of the thyrotoxic patients were admitted from the Surgical Clinic, St. Göran's Hospital and chosen for radioiodine treatment by Dr. Hj. Wijnbladh.

SUMMARY

Hyperthyroid patients and euthyroid patients with cardiac failure were treated by I^{131} in order to cause a subtotal destruction of the thyroid. The iodine concentrating function of the thyroid was followed by repeated tracer investigations with I^{131} after a single therapeutic dose. In most cases an initial depression of the function occurred during the first months after treatment to be followed by a regeneration of the function up to a level usually below that existing before treatment. The practical importance of these findings for the management of treatment is pointed out.

ZUSAMMENFASSUNG

Hyperthyreotische Patienten und euthyreotische Patienten mit Herzfehlern sind zum Zwecke einer subtotalen Destruktion der Schilddrüse mit J^{131} behandelt worden. Die Möglichkeit der Schilddrüse Jod zu konzentrieren wurde im Anschluss an eine therapeutische Einzeldosis mit Hilfe von wiederholten Spuruntersuchungen verfolgt. In den meisten Fällen erfolgte während der ersten Monate nach der Behandlung eine initiale Funktionsherabsetzung, die von einer Erholung der Funktionsfähigkeit abgelöst wurde; letztere stieg gewöhnlich bis zu einer Grenze, die unterhalb der Drüsenfunktion vor Beginn der Behandlung lag. Die praktische Bedeutung dieser Befunde für die Ausführung der Behandlung wird hervorgehoben.

RÉSUMÉ

Des malades hyperthyroïdiens et des malades à thyroïde normale atteints d'insuffisance cardiaque ont été traités par l'I^{131} afin de provoquer une destruction subtotale de la thyroïde. La fonction de concentration de l'iode de la thyroïde a été suivie grâce à des épreuves répétées avec des doses traceuses d'I^{131} après l'administration d'une seule dose thérapeutique. Dans la plupart des cas une diminution initiale de la fonction s'est produite dans les premiers mois après le traitement; puis elle a été suivie d'une régénération de la fonction jusqu'à un niveau généralement inférieur au niveau primitif. Ces résultats ont une importance pratique pour la conduite du traitement.

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THE TROELL-JUNET SYNDROME

by

Sherwood Moore

There is an uncommun if not rare complex consisting of acromegaly, toxic goiter (usually nodular), diabetes mellitus (in four of five cases personally observed) and hyperostosis of the vault of the skull. This condition is sufficiently distinct that it may be considered as a clinical entity. The only descriptions found in the literature are those of ABRAHAM TROELL and ROBERT M. JUNET. For that reason it is proposed that the condition be called the Troell-Junet syndrome.

Some 20 odd years ago, an investigation of the roentgen evidence of symmetrical hyperostosis of the vault of the skull (now best known as a feature of the Morgagni syndrome of FOLKE HENSCHEN) produced a group of cases with a characteristic diffuse thickening of the vault of the skull. The writer in a former publication called this group *hyperostosis calvariae diffusa*. Among them was an example of the most extreme thickening of the calvaria observed until recently.

Osteitis deformans of the skull when extremely developed, produces more thickening than found in hyperostosis calvariae diffusa. Osteitis deformans, however, has a characteristic bone texture and deformity whereas diffuse hyperostosis has, except for greater density, a normal roentgen bone texture and configuration.

Case 1. (Fig. 1) M. S. (3719) a white married woman, 42 years of age, Para VI, was admitted to the Barnes Hospital with symptoms of thyroid toxicity of two years duration. Since the age of 19, nodule in the right lobe of the thyroid; during the past 18—19 years, gradual enlargement of the hands and feet and, for 15 years, coarsening and enlargement of the nose, lips, mandible, and superciliary ridges. On admission she was a typical stabilized acromegalic. Following reduction of the basal metabolic rate to a value of 33 % plus, partial thyroidectomy was undertaken. A nodule 8 cm in its greatest dimension was removed from the lower pole of the right lobe. The pathologic examination revealed the presence of multiple adenomata filled with deep staining colloid. The postoperative course was uneventful. The patient regained good health.

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Fig. 1. Case 1. Small size of sella turcica.

In the past 17 years five additional similar cases have been found at the Barnes Hospital in the roentgen examination of the skull in well over 16,000 individuals of all ages, about equally divided between the sexes.

A brief description of the first four of these follows:

Case 2. (Fig. 2) V. R. W. (75118) female, white, married, Para VI, was admitted with acromegaly, thyrotoxicosis and diabetes mellitus. The basal metabolic rate was 32 % plus. There was no thyroid enlargement. During one of five later hospital admissions, a chromophile adenoma of the pituitary was removed.

Case 3. C. N. (82139) female, aged 47, white, married, Para II, with a nodular toxic goiter, acromegaly and obesity. Basal metabolic rate: 26 % plus. 30 years history of goiter with toxicity as a recent development. Following thyroidectomy in 1940, improvement. In 1952, the patient was admitted to the Psychiatric Service whence she was discharged with the diagnosis of involutional psychosis of paranoid type. The sella turcica was within normal limits.

Case 4. (Fig. 3) R. J. (38669) female, aged 23, white, married, with a toxic diffuse goiter, diabetes mellitus, acromegaly and headache. An eosinophilic pituitary adenoma was removed surgically.

Case 5. (Fig. 4) N. H. (111445) female, aged 51, white, married, with acromegaly, nodular toxic goiter and diabetes mellitus. Height 167 cm. Weight 90 kg. The detailed history was not available hence the basal metabolic rate and treatment are not included.

The history of the sixth case is given more fully because it came to autopsy.

Case 6. (Fig. 5) G. W. (207967) female, aged 41, colored, married, referred from the Dental Clinic (Professor L. W. PETERSON) to the Medical Service with a painful osteoma of the right mandible, acromegaly of several years duration and diabetes mel-

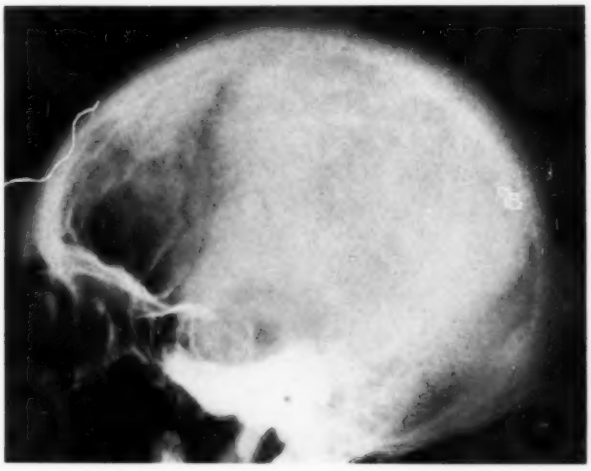

Fig. 2. Case 2. Enlarged sella turcica.

litus. There was a nodule 3 × 3 cm in the left lobe of the thyroid; basal metabolic rate: 40 % plus. Height 152 cm. Weight 70 kg. The osteoma of the mandible was excised without difficulty or incident and pathologically was found to be an osteoma durum. The immediate postoperative course was uneventful. However, on about the third day, fever of an undetermined origin developed, and was followed by a terminal hyperthermia and death.

Dr. David E. Smith, Assistant Professor of Pathology, kindly supplied the protocol of the autopsy, the findings of which were:

Macroscopically: Adenoma of the pituitary; splanchnomegaly; acromegalic changes of the skeleton and skin; nodular hyperplasia of the thyroid; hyperplasia and adenoma of the parathyroids; necrosis and interstitial hemorrhage in the pituitary adenoma; distension of the diaphragma sellae with compression of the floor of the third ventricle.

Microscopically: The pituitary was almost completely necrotic; tinctorial pallor of the cells in the anterior hypothalamus; the skull had a marked amount of irregular bone formation between thick trabeculae; hypothalamus: para-ventricular nuclei of the anterior hypothalamus have areas of definite pale staining neurons with an increase in glial cells; thyroid: the acini were large and filled with colloid; no vacuolization of the periphery of the colloid material; epithelium of very low cuboidal type; pancreas: the ducts show marked proliferation, the acinar cells having a tendency to adenomatous arrangement; the islets were small but numerous and not too well delineated from the surrounding acinar tissue; the cell nuclei varied slightly in size and had a small amount of cytoplasm; adrenals: the cortical cells contained a large amount of fat; a few groups of cortical cells were eosinophilic and non-vacuolated; some focal collections of lymphocytes present in the cortex; medulla: not abnormal.

In 1938 Troell and Junet both reported examples of acromegaly complicated by thyroid toxicity and hyperostosis of the skull, two cases by the former, and three by the latter. Troell's Case 1, a 47 years old

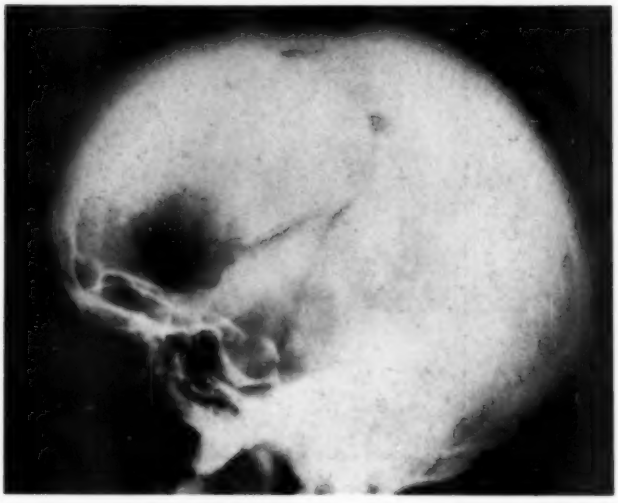

Fig. 3. Case 4.

Approximately normal size of sella turcica. The osteoplastic flap participates in the hyperostosis.

woman was a typical acromegalic with a nodular toxic goiter and hyperostosis frontalis interna. At autopsy a *chromophobe* hypophyseal adenoma was found. The weight of the pituitary was 7 gms. His Case II was one of acromegaly in a 41 years old woman who had multiple thyroid adenomata with toxicity. The sella turcica was not enlarged. There was hyperostosis frontalis interna and the skull cap "was rather thick".

(Only a photostatic copy of the article was available, hence the poor quality of reproduction of the radiographs. However, there is an undoubted hyperostosis frontalis interna and, in the opinion of the writer, a hyperostosis calvariae diffusa.)

JUNET's cases were women, 73, 60 and 52 years of age respectively. All three came to autopsy.

His Case I was clearly an example of hyperostosis frontalis interna. The frontal bone was about 12 mm thick and over the hyperostotic zone measured 20 mm. The occipital was 11 mm in thickness. Microscopically there was new bone formation in the hyperostotic areas. There was a colloidal goiter. The sella turcica was enlarged and contained an eosinophilic adenoma.

His Case II had a thyroid adenoma, excised 17 years previously; at that time there was evidence that she was acromegalic. Later an eosinophilic adenoma of the pituitary was removed transnasally. Death from diabetes followed later. At autopsy the skull was found to be of normal thickness.

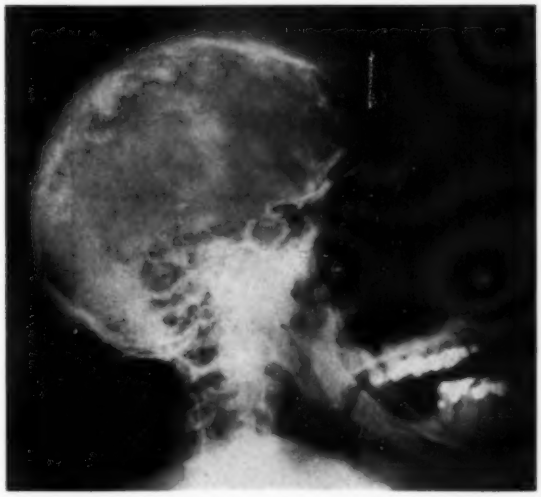

Fig. 4. Case 5.

Combination of hyperostosis frontalis interna and hyperostosis calvariae diffusa. Enormous gnathion—obelion dimension. Sella turcica approximately normal in size.

His Case III, the youngest acromegalic subject, had an enlarged right lobe of the thyroid and suffered from fatigue, asthenia and headache. Death followed thyroidectomy. At autopsy the skull was found to be extraordinarily thick, the frontal, occipital and temporal bones measuring 14, 18, and 5 mm, respectively. The skull cap was double the normal weight and no diploe were visible. Microscopic study of the *occipital bone showed new formed bone in the diploe* (italics by S. M.). There was a very large sella turcica containing an eosinophilic adenoma.

The writer, for the purpose of comparison, worked out a method of measuring in the average normal male and female those roentgen dimensions of the skull, the least subject to distortion. Tabulation in mm of the last five cases herein against the normal gives:

	Normal	No. 2	No. 3	No. 4	No. 5	No. 6
Nasion—Occipital Point	207.7	200	211	207	?	205
Porus—Vertex	133.5	135	138	135	135	141
Gnathion—Obelion	265	267	?	?	333!	?
Lambda—Bregma	138.4	145	145	145	?	135
Bregma—Glabella	98.8	102	115	105	?	119
Mid-Sagittal (thickness)	7.2	14	17	9	10	19
Mid-Frontal (»)	6.2	16	13	9	23	21
Mid-Orbital Plate (thickness)	2.2	5	3	2	2	1
Orbital Plate Length	63.9	60	55	65	40	52

Fig. 5. Case 6.
Another example of hyperostosis calvariae diffusa.

Question marks indicate that the points for measuring could not be established. This is especially true of the gnathion—obelion distance because in roentgen films of conventional size, the point of the chin is not always shown.

In an article in press (7) the writer claims that in uncomplicated acromegaly the bone changes in the skull are confined to its visceral division. The vault does not thicken nor is the sella turcica always enlarged. Roentgenologically the capacity of the cranial cavity is not altered except a slight diminution occurs through the expansion of the pneumatic cells of the frontal, ethmoid and mastoid bones. The dimension, bregma—glabella (intracranial measurement) is diminished by the degree of expansion of the frontal sinus posteriorly. More striking is the shortening of the pars orbicularis frontalis from the same cause. The overgrowth of the mandible increase the gnathion—obelion dimension greatly as seen in case No. 5 in the above table.

The morphologic group of hyperostosis cranii that the writer has named hyperostosis calvariae diffusa, number 199 females and 22 males. Only numbers 1, 2, 3 and 4 are among the 199 in the original study (2 % plus). Cases 5 and 6 were later observed. There were no male cases. It is to be kept in mind that idiopathic hyperostosis of the skull is far more frequent in women than in men. HENSCHEN writes that hyperostosis frontalis interna occurs 100 times in women to once in men. Including all four of the writer's morphological types the ratio approximates 92 to 8.

Fig. 6.
Nebula frontalis clearly seen.

Discussion

Thyroid abnormality accompanying acromegaly is so well known and of such frequency as to suggest that the abnormality of the former is an essential part of the latter. ATKINSON collected the autopsy reports of acromegaly and found only 15 % with a normal thyroid. Sixteen cases had adenomata. Data on toxicity were lacking.

DAVIS reported that thyroid enlargement existed in one-half of 166 acromegalics. In one example, there was a recurrent thyroid adenoma some years following partial thyroidectomy. Over a 15-year period of observation, *the vault of the skull thickened*. This is to be compared with JUNET's Case II.

Search for a report of an example of exophthalmic goiter in acromegaly was unsuccessful. There was none among the 33 acromegalics in the writer's material.

In 456 cases of hyperostosis cranii of all four types there were only three with exophthalmic goiter, all in the group that the writer has named Nebula frontalis. (See Fig. 6.) The existence of such a group of skull changes is generally denied.

Conclusions

All of the 11 cases of TROELL, JUNET and MOORE were acromegalic *women*. Ten had enlarged thyroid glands, usually nodular. Exceptionally, the writer's Case 2 had an elevated basal metabolic rate. Seven had diabetes mellitus. In four the records in respect to that disorder are

lacking. All but one, JUNET's Case II, had a thickened calvaria. Three presented hyperostosis frontalis interna, two being TROELL's cases and one JUNET's. The writer's Case V also showed this, in combination.

TROELL appears to have been led to report his cases as examples of the Morgagni syndrome complicated with acromegaly and thyrotoxicosis. He did not mention the clinical features usually present in that syndrome, namely, headache, obesity, male type of facial hair growth in women, and psychic and muscular insufficiency. JUNET did not record them either. It is a fact that there is, sooner or later, a diffuse thickening of the calvaria in hyperostosis frontalis interna if the two do not coexist. The latter has been observed preceding the former.

Six pituitary adenomata were verified either by autopsy or operation. TROELL's Case I, on autopsy, had a chromophobe adenoma. All three of JUNET's cases were eosinophilic adenomata as were the writer's Cases 2 and 4. This last two and probably JUNET's Case II, were submitted to surgical operation because the vision was in jeopardy. In the writer's Case 6, the adenoma was too necrotic to permit of an opinion as to its histologic type.

This communication is but incidental in an investigation of the idiopathic symmetrical hyperostosis of the vault of the skull. Different forms or degrees of these variations are known as 'l'hyperostose frontale interne' (MOREL), the Stewart-Morel syndrome (VAN BOGAERT), metabolic craniopathy (MOORE), Morgagni's syndrome (HENSCHEN), 'le syndrome de Morgagni-Morel' (CALAME), and other less well-known terms.

All writers on this subject report an overwhelmingly predominant female incidence. It has not been established that the cause of hyperostosis cranii lies in the pituitary although strongly points in that direction.

It is noteworthy that the 11 cases in this paper were women. It is equally noteworthy that a male example of acromegaly, with diffuse hyperostosis of the skull, thyroid hyperplasia or nodulation and diabetes mellitus, is yet to be found in the literature, or perhaps observed. If closer scrutiny were made of acromegalics, diabetics and those with goiter or hyperostosis of the skull, more examples of the condition described would be found.

In conclusion the writer firmly believes that these 11 cases justify the title, Troell-Junet syndrome.

SUMMARY

An investigation of idiopathic symmetrical hyperostosis of the vault of the skull conformed a correlation between acromegaly with diffuse hyperostosis of the skull, toxic thyroid and diabetes mellitus and for which clinical entity the term 'Troell-Junet syndrome' is suggested. Six illustrative cases are presented. Certain roentgen dimensions of the skull in five of the cases with comparisons with the normal are given.

ZUSAMMENFASSUNG

Eine Untersuchung der idiopathischen symmetrischen Hyperostose des Schädeldaches bestätigte eine Beziehung zwischen diffuser Hyperostose des Schädels, toxischer Thyreoidea und Diabetes mellitus. Für dieses klinische Gesamtbild wird der Name Troell-Junet's Syndrom vorgeschlagen. 6 illustrative Fälle werden wiedergegeben. Gewisse röntgenologische Schädeldimensionen werden in 5 der Fälle angegeben und mit normalen Fällen verglichen.

RÉSUMÉ

L'étude de l'hyperostose symétrique idiopathique de la voûte du crâne a confirmé qu'il existe une corrélation entre l'acromégalie avec hyperostose diffuse du crâne, la thyréo-toxicose et le diabète sucré, entité clinique pour laquelle le terme de syndrome de Troell-Junet est proposé. L'auteur en présente six cas. Dans cinq des cas certaines dimensions radiologiques du crâne sont indiquées et comparées aux dimensions normales.

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FROM THE DEPARTMENT OF HISTOLOGY, THE MEDICAL SCHOOL, GOTHENBURG, SWEDEN

THE ELIMINATION OF ERRORS IN ROENTGEN MICRORADIOGRAPHY

by

S.-O. Brattgård, O. Hallén and *H. Hydén*

Roentgen microradiography employing soft roentgen radiation (5, 7) is an excellent contribution to the arsenal of quantitative cytochemical methods. It permits for the first time the determination of the total dry weight of a chemical fraction within a single cell. The method may be used with great accuracy (3, 5). A prerequisite is naturally that the most important errors of the method are eliminated or greatly reduced. If this is not done the total error of the method may be as great as that reported by ENGSTRÖM and MALMSTRÖM (8) and LINDSTRÖM (13) *i. e.* $\pm$ *26 % of the determination of mass per unit area.* This figure is obtained by adding the errors (13) of the reference system (11 %), of the photographic-photometric procedure (23 %) and a theoretically calculated error of 5 %. The present article shows how these errors may be further reduced.

The roentgen method is based on the fact that the carbon, nitrogen and oxygen in the tissue account for the main part of the absorption of soft roentgen radiation (7). These elements taken in the same proportions as in proteins are assumed to be responsible for the total absorption (5, 7, 13). A correction is made for the presence of hydrogen. However, elements other than C, N, O and H contribute to the total absorption. The presence of these other elements (2, 3, 4, 7), therefore, produces a positive systematic error, ≤ 5 %.

This value is erroneously used as a random error by ENGSTRÖM (8) and LINDSTRÖM (13, 14) in their calculation of the error of the method. It is clear that the distribution of these other elements in a cell may vary, and so give rise to a random error, but one which belongs to the total random error of the biologic material (4).

The error of the reference system. The reference system is made with thin nitrocellulose films arranged in the form of a step wedge (2, 5, 7).

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LINDSTRÖM (13) calculates the error to be $\pm$ 11 %, based on the determination of 21 duplicates. This represents the error in one single determination according to the formula $\varepsilon = \sqrt{\frac{\Sigma d^2}{2n}}$; d is the difference between the two values in the duplicate and n is the number of the duplicates.

The reference system in ENGSTRÖM and LINDSTRÖM's (7, 13, 14) case is also composed of foils but they are not weighed. The weight of these foils may be calculated statistically. Of a pair of observations, A_1 and A_2, only A_1 is numerically determined. Then the statistical expression for A_2 is: $A_1 = \pm \sqrt{\frac{\Sigma(d)^2}{n}}$ or $A_1 = \pm \sqrt{\varepsilon_{A_1}^2 + \varepsilon_{A_2}^2}$.

Thus the error in the foils used by LINDSTRÖM is

$$\sqrt{11^2 + 11^2} = \pm 16\ \%.$$

Our investigation (3), comprises *1,400 determinations*. These show clearly that the weight of *two adjacent parts* of the foil made according to ENGSTRÖM and LINDSTRÖM (14) can vary up to 55 %. Using a special apparatus for the preparation of these films (3, 4, 5, 9), we found that the corresponding variation was 18 %. This error was so large that we had to abandon the gravimetric method. The fact is that *every cellulose film* produced on a water surface, even if made with the greatest care, varies considerably in thickness in adjacent parts. We have repeatedly emphasized (2, 4, 5, 6, 9, 10) that the same part of the reference system used for the absorption measurements must also be measured with consideration to mass. A gravimetric method requires a surface of at least 1 cm². For the Roentgen ray absorption measurements we use a surface of the film of 0.2 mm² constituting each step of the reference system. In the same area the mass of the reference system is now determined interferometrically according to HALLÉN and INGELSTAM (10) and DJURLE and HALLÉN (6). This method has an accuracy of $\leq \pm$ 1 % (4, 6). It is quite true that it is not worth while to reduce the error in the reference system (in LINDSTRÖM's case $\pm$ 11 %) if the photographic-photometric error amounts to 23 %. But as soon as this last error is reduced (by us, to $\pm$ 1.5 %), the accuracy of the method depends upon the reference system. Therefore, the two errors ought to be reduced to the same level.

In the photographic-photometric procedure used by ENGSTRÖM and LINDSTRÖM (7, 8, 13, 14) the primary radiograms is enlarged by photomicrography. These workers determined the error by measurement of 35 duplicates (13) using sections of biologic material and found it to be $\pm$ 23 %. This error also includes certain biologic variations (13).

To determine the error of the photographic-photometric procedure and to avoid the error due to lack of homogeneity in the biologic material

we used a reference system as a test object. Our procedure was as follows: The same reference system was exposed 6 to 8 times on the same Kodak 250 plate with stabilized illumination and constant exposure time. The density was recorded by means of a Kipp and Zonen microphotometer model A[1] according to Moll. The results are shown in Table 1.

Table 1

Variation of the photometer deviations in mm of the same cellulose film in seven secondary enlargements

Photometer values in mm							σ	ε_m
92	81	84	75	69	67	57	± 11.8	± 4.45
65	59	52	54	46	47	28	± 11.8	± 4.46
35	36	53	73	67	55	66	± 15.0	± 5.68
2	9	21	41	35	30	33	± 14.4	± 5.45
59	60	63	65	65	73	66	± 5.2	± 1.13
34	35	33	28	35	35	33	± 2.5	± 0.94
64	59	59	56	57	60	49	± 5.2	± 1.74
31	30	20	21	21	25	35	± 8.5	± 2.23
51	57	61	61	60	58	54	± 3.5	± 1.43
69	79	81	82	79	78	75	± 4.7	± 1.66
Mean value in mm							± 8.24	± 2.92
Mean value expressed in folio equivalents (1 folio equivalent = 25 mm)							± 37.0 %	± 11.7 %

The standard deviation is ± 37 % and the error of the mean ± 12 %. A further test was carried out by the determination of 80 duplicates. σ turned out to be ± 69 % and the error of the mean ± 48 %. Thus the largest error is due to the secondary enlargement of the radiogram. We have therefore abandoned this method and use instead a specially constructed microphotometer (1, 2, 5, 12) with linear amplification to measure the density directly in the primary radiogram. The random error in our photographic-photometric procedure was determined in the following way:

Ten reference systems were each exposed five times in the roentgen microspectrograph at 8—10 Å on Lippmann films under the same conditions (Table II). The density was measured by the microphotometer. The amplification was so adjusted that the values of step I and III, respectively, were the same in every transmission curve. Variation in the value of step II (see Table II) is then a measure of the accuracy of the whole procedure. The recorder and the radiogram were moved at a constant velocity, the most accurate determination of the density level therefore being an integration of the curves. This was done by means of a Ross' planimeter whose accuracy had been tested (11). The results listed in Table II shows the error of this procedure to be ± 1.7 %. In

the actual case this corresponds to an error of ± 0.034 mg/μ^2. If the biologic section weighs $2.5 \cdot 10^{-9}$ mg/μ^2 this means an error of ± 1.5 %.

Table II

Control test. Photometer values of step II of the reference system

Photometer unit					σ	ε_m
23	23	23	24	24	± 0.5	± 0.22
23	23	24	24	24	± 0.5	± 0.22
25	25	24	26	26	± 0.9	± 0.39
24	27	24	24	25	± 1.3	± 0.59
18	21	19	21	19	± 1.3	± 0.59
18	19	18	20	18	± 0.9	± 0.39
18	17	17	20	18	± 1.2	± 0.55
20	17	18	17	18	± 1.2	± 0.55
19	19	19	18	19	± 0.5	± 0.22
20	21	21	22	19	± 1.1	± 0.50
Mean value in photometer units ..					± 0.9	± 0.42
Mean value in folio equivalents (1 folio corresponds to 25 photometer units)					± 3.6 %	± 1.7 %

Conclusion

Summarizing our results the following statement can be made. ENGSTRÖM and LINDSTRÖM calculate the random error in roentgen microradiography to be $\pm \sqrt{5^2 + 11^2 + 23^2} = \pm 26$ %. This calculation is statistically incorrect. According to our results the random error of the method may be considerably reduced. The error of the reference system may be lowered to ± 1 % and that of the photographic-photometric procedure to ± 1.5 %.

SUMMARY

The authors report their results in roentgen microradiography and show that the random error previously calculated as being $\pm \sqrt{5^2 + 11^2 + 23^2} = \pm 26$ % by ENGSTRÖM and LINDSTRÖM may be considerably reduced. The error of the reference system need not exceed ± 1 % and that of the photographic-photometric procedure, ± 1.5 %.

ZUSAMMENFASSUNG

Die Verf. berichten über ihre Ergebnisse mit der Röntgenmikroradiographie und zeigen, dass die zufallsbedingten Fehler, welche früher von ENGSTRÖM und LINDSTRÖM mit $\pm \sqrt{5^2 + 11^2 + 23^2} = \pm 26$ % berechnet worden waren, erheblich reduziert werden können. Die Fehlergrösse des Referenzsystems braucht ± 1 nicht zu übersteigen und die der photographisch-photometrischen Prozedur braucht nicht grösser als ± 1.5 % zu sein.

RÉSUMÉ

Les auteurs présentent leurs résultats de microradiographie roentgen et montrent que l'erreur accidentelle qui, selon les calculs de ENGSTRÖM et de LINDSTRÖM s'élève à $\pm \sqrt{5^2 + 11^2 + 23^2} = \pm 26$ %, peut être considérablement réduite. L'erreur due au système de référence ne doit pas dépasser ± 1 % et celle due à la technique photographique et photométrique, ± 1.5 %.

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR: PROFESSOR FOLKE KNUTSSON),
UNIVERSITY HOSPITAL, UPPSALA, SWEDEN

A TIME-MARKER FOR UROGRAMS

by

Olof Willner

For over a year a special dial for recording the timing of urograms has been in use in this department. Its description may be of interest.

The device consists of a sheet of 'Plexiglas' (acrylic plastic) on which the hours are represented by lead shot, with the exception of 12 o'clock which is indicated by an arrow. The hands are made of the same material and contain fine lead pointers. The dial is marked with H (Höger = right)

Fig. 1. Urography dial showing side markers
(*H* on the right and *V* on the left; can be changed if desired).

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Fig. 2. Representation of the dial on the urogram.

and V (Vänster = left), which may be changed to R and L, D and G, D and S, etc., to meet requirements. A finger piece attached to the centre pin is fitted on the reverse side, so that the marker may be used upside down when the patient is lying prone. An arrow, painted black, between 12 o'clock and 1 o'clock indicates the direction in which the hands are to be moved.

The device may be placed anywhere on the casette although perhaps most conveniently on the lower edge, and fastened with a piece of adhesive tape.

When the injection is performed, the hands are set at 12 o'clock and reset with the appropriate time for each film. The times reproduced on the films are seen at a glance, and in practice, the method of marking has proved to be most convenient.

The device is only 5 mm thick, and may be used with both the old and the new type of Bucky couches. It is manufactured by AB Elema-Järnh, Stockholm.

SUMMARY

A short description of a time-marker for urograms.

ZUSAMMENFASSUNG

Eine Zeitmarkierungsanordnung für Urogramme wird kurz beschrieben.

RÉSUMÉ

Brève description d'un marqueur de temps pour les urographies.

FROM THE ROENTGEN DEPARTMENT (DIRECTOR: PROFESSOR KNUT LINDBLOM), KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

A SIMPLE METHOD OF ENSURING CORRECT CONCENTRATION OF BARIUM CONTRAST MEDIA

by

Ove Mattsson

In order to obtain an optimal result when using fluid barium contrast media, the employment of a correct mixture is of considerable importance. The concentration of barium must not be so high that detail is lost through the density of the fluid, nor so low that thin coatings of the medium cannot be visualized. The correct proportion varies with the type of examination to be made. Barium meals for studies of the stomach and the duodenum require a higher concentration than barium enemas. This is partly on account of anatomic factors and partly by reason of the examination technique.

Normally the contrast medium is prepared in bulk quantities for the requirements of the day. Even if the contrast medium is accurately made up there may be considerable variations in the percentage of barium sulphate in samples used throughout the period. Sedimentation in the storage containers and inadequate or infrequent stirring may produce considerable changes in the concentration of the medium. Untrained personnel and random mixing are other sources of varying quality in the contrast medium. With enema suspensions, hot or cold water is often added for temperature correction. When this is done the original composition will be changed, and the standard concentration no longer prevail.

If, during screening, the examiner finds that the contrast medium is too thick or too thin, the possibility of correcting the composition by dilution or addition of barium powder is fairly small. It is not possible to judge the concentration of the medium by its external appearance. It is often better to prepare a fresh quantity of the barium suspension.

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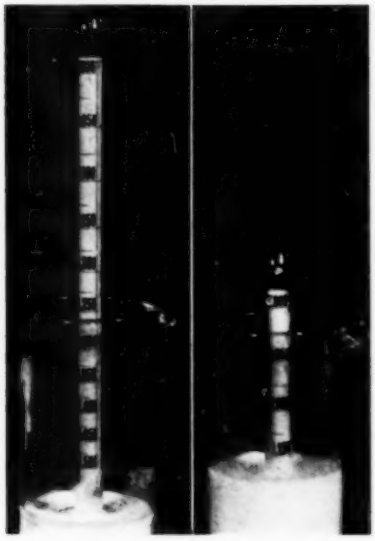

Fig. 1. Variations in specific gravity of suspensions for different radiographic purposes are easily determined with an areometer. Note the latitude. To the left a barium meal and to the right an enema, both of suitable concentrations. The preparation is Unibaryt and the values are 1.55 and 1.15 respectively.

A simple method for the exact determination of the concentration would be of great value, partly to facilitate the preparation of a standard medium and partly to obtain accurate control of the medium to be used, immediately prior to the examination.

The radio-opacity of the contrast media is due to the heavy insoluble barium sulphate. The higher the quantity of barium sulphate in a suspension, the higher will be the opacity. Thus, the specific gravity is a very sensitive indicator of the composition of the medium. Independently of make, size of particles, type of stabilizer or other ingredients, the heavy barium sulphate by its concentration in the suspension produces the radio-opacity, which is thus intimately correlated to the specific gravity of the suspension.

The variations, when studied with a suitable instrument, are very pronounced and are easily determined, as shown in Fig. 1. An areometer was placed in two different barium suspensions, a barium meal and an enema, both of suitable concentration. The contrast preparation was Unibaryt and values of 1.55 and 1.15, respectively, were obtained.

In order to determine the importance of other substances present in preparations of different manufacture, various suspensions of the same specific gravity have been studied radiographically. The added components vary from the ordinary stabilizing ingredients of the albumen type to components giving increased viscosity, such as carboxymethylcellulose. Both fine colloidal and coarse suspensions of barium are included in the series. Six preparations, carefully stirred, all had the same specific gravity of 1.30. They have been roentgenographed on a film without screens at 70 kV in similar glass tubes. There were only small differences in opacity as observed in Fig. 2. Measurements on the original films show that the differences in photographic density did not maximally exceed the value of 0.15 when the total density was about 1.5: that is, along a straight-lined section of the density curve. The preparations tested were Uni-

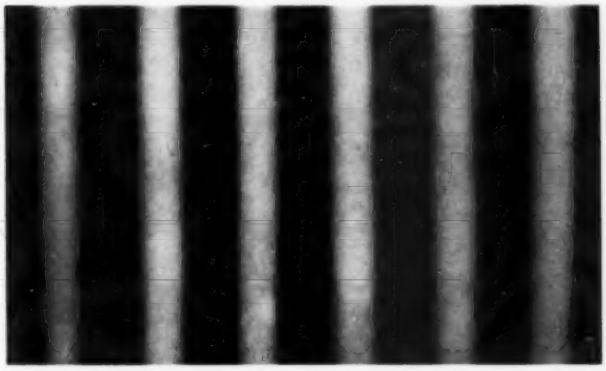

Fig. 2. A comparison between six different preparations. Every suspension has the specific gravity of 1.30. Only small differences in radio-opacity are recorded (Unibaryt, Lumibar, Pharmabaryt, Astrabaryt, P. 16 and Neobar, respectively).

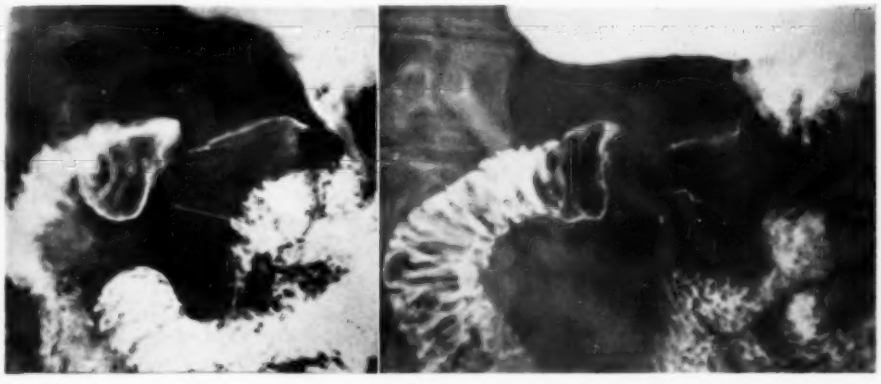

Fig. 3. Fig. 4.

Figs. 3 and 4. Two radiographs of the stomach. The meals had a concentration corresponding to specific gravities of about 1.60 and 1.45 (Unibaryt) respectively.

baryt (Röhm and Haas, Darmstadt), Lumibar and Pharmabaryt (Pharmacia, Upsala), Astrabaryt (Astra, Södertälje), P. 16 — a Swedish experimental preparation, yet without name — and Neobar (E. Merck, Darmstadt).

The differences in specific gravity seem to be much lower than the values presented in a comparison by REINDELL in 1937. At that time, however, the preparations were not so uniform as now.

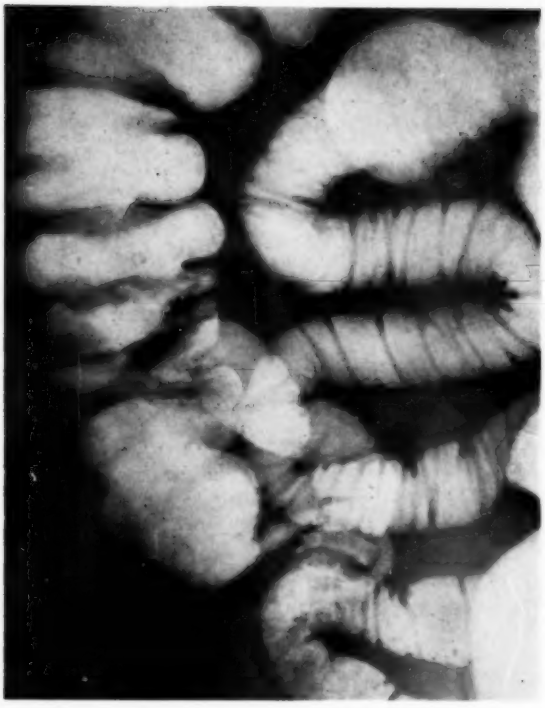

Fig. 5. The caecum and ascending colon examined with an enema which has a specific gravity of about 1.15 (Unibaryt).

For the determination of the specific gravity of the contrast media, the author has developed a special areometer, graduated from 1.00 to 1.60. With this instrument many measurements have been made on the specific gravity of the contrast fluids used in routine work. Their concentrations have been varied intentionally, and the results of the measurements have been compared with the quality of the radiographs, with special regard to the reproduction of the contrast-filled organs. With the compression technique regularly used in Sweden for the examination of the stomach and duodenum with the patient both in the vertical and horizontal positions, a suitable concentration of the contrast medium corresponds to a specific gravity of 1.45 to 1.60. A suspension of this concentration seems to be ideal for studies of the mucous membrane, without being too thick or ray-absorbing. Two similar radiographs with

concentrations of the barium meal corresponding to 1.60 and 1.45 respectively are reproduced in Figs. 3 and 4. These projections of the stomach are designed of course, to show the pyloric part and the duodenal cap. For examinations of the large intestine with an enema, a concentration corresponding to a specific gravity of about 1.15 seems to be satisfactory. A radiograph from a series made with a concentration corresponding to a specific gravity of about 1.15 is reproduced in Fig. 5. A voltage around 80 kV was used.

Fig. 6. A simple areometer designed for determinations of barium suspensions. Simple scale graduated from 1 to 10 instead of specific gravity.

Naturally, a determination of the specific gravity with an areometer principally provides the possibility of using a preparation of the same concentration every day. A straight transfer of values for a certain preparation, as given above, to other preparations cannot be effected. The small differences in opacity, shown in Fig. 2, have less importance than other differences in properties, such as viscosity and wetting power, which to a great extent differ. These factors influence the optimal concentration so that other values may be preferable than those referable to the opacity alone. Furthermore there are small variations in the examination technique — different degrees of compression etc. — which may influence the optimal concentration. The values discussed above must therefore be looked upon only as guides.

There are also other factors affecting the radiographic result, for example the size of the patient or an undesired fluid content in the organs examined. As a matter of fact, it is always preferable to use the same standard concentration for the respective examinations.

The advantage of using an areometer is to facilitate the establishment of constant factors as regards the contrast media. It is always possible to reproduce a desired optimal concentration for an actual preparation.

The special areometer is particularly suited for use in barium contrast media. Unlike ordinary areometers, which are made of glass, it is con-

structed of an unbreakable plastic material. It is small and convenient in use. In place of a graduation in specific gravity, it has a simple scale from 1 to 10, enemas corresponding to values of about 1 and barium meals of about 7. The scale is easy to read in darkened radiographic rooms. An adjustable and distinct index is added in the shape of a coloured sliding ring around the graduated tube. By pushing the ring to the desired position along the scale, the areometer value is not affected should a coating of opaque contrast medium cover the scale.

The appearance of the areometer is seen in Fig. 6. Its use is self-explanatory. It may be added that the areometer may be conveniently kept standing in a small vessel and that it is preferable to use separate instruments for barium meals and enemas.

The areometer is manufactured by Philips Roentgen, Stockholm.

SUMMARY

The author discusses the value of the determination of the specific gravity of barium meals and enemas as a method for obtaining optimal opacity. An areometer, made of plastic material and especially developed for barium suspensions, is described.

ZUSAMMENFASSUNG

Der Verf. diskutiert den Wert der Bestimmung des spezifischen Gewichtes von Bariummahlzeiten und Bariumeinläufen als eine Methode zur Erhaltung optimaler Opazität. Ein Areometer, der aus plastischem Material hergerestellt und besonders für Bariumsuspensionen konstruiert ist, wird beschrieben.

RÉSUMÉ

L'auteur étudie l'intérêt de la mesure du poids spécifique des bouillies et des lavements barytés pour obtenir l'opacité la plus convenable. Il décrit un aréomètre en matière plastique spécialement construit pour les suspensions de baryte.

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PROCEEDINGS OF THE 17TH CONGRESS OF THE NORTHERN ASSOCIATION OF MEDICAL RADIOLOGY

(NORDISK FÖRENING FÖR MEDICINSK RADIOLOGI) HELD AT AARHUS, DENMARK, 13TH—15TH JUNE 1951

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	Dr. AAGE WAGNER,	Denmark
	Mrs. ASTRID ISAGER,	Denmark
Honorary Presidents of the Congress:		
Diagnostic Section:	Prof. P. FLEMMING MÖLLER,	Denmark
	Dr. W. EDGREN,	Finland
	Dr. J. FRIMANN-DAHL,	Norway
	Prof. O. OLSSON,	Sweden
Therapeutic Section:	Dr. JENS NIELSEN,	Denmark
	Prof. S. MUSTAKALLIO,	Finland
	Dr. AXEL SCHEEL,	Norway
	Dr. MAGNUS STRANDQVIST,	Sweden
Secretaries of the Congress:		
Diagnostic Section:	Dr. O. BROBECK,	Denmark
	Dr. C.-E. JOHANSON,	Finland
	Dr. P. AMUNDSEN,	Norway
	Dr. NILS EDLING,	Sweden
Therapeutic Section:	Dr. SIGVARD KAAE,	Denmark
	Dr. KAI MALMIO,	Finland
	Dr. JOH. SLÖHRDAL,	Norway
	Dr. SV. HULTBERG,	Sweden

The Congress was opened in the Speech Room of the University, the Patroness of the Congress, Her Majesty Queen Alexandrine, honouring the Association with her presence.

The Rector of the University, Professor FRANZ BLATT, welcomed the Members of the Congress to the University.

The President, Professor CARL KREBS then delivered the following speech of welcome:

Your Majesty,
Mr. Rector,
Ladies and Gentlemen,

In my capacity as President of the Northern Association of Medical Radiology I now have the honour of opening the 17th Scandinavian Radiological Congress, and bid all of you a heartfelt welcome.

I wish to extend a hearty welcome and to offer my special thanks to the Patroness of the Congress, Her Majesty Queen Alexandrine, who, with our late King, stood as a shining example for all of us during the difficult years which our country experienced.

It is a great pleasure to the City of Aarhus and its inhabitants that your Majesty returns year after year. The visit is one to which we all look forward. We owe a debt of gratitude to your Majesty for the immediate and gracious manner in which, without hesitation, you consented to be Patroness of our Congress.

I also take this opportunity of thanking the Authorities of the City of Aarhus and the University of Aarhus for readily opening their doors and bidding us welcome when approached that the Congress be held here. I therefore ask Alderman CHR. NIELSEN and Rector Professor BLATT to accept on behalf of the City of Aarhus and the University of Aarhus our warm thanks.

It is an old custom in our Association that we, at the opening ceremony, pay tribute to those Members who have passed away since the last Congress.

One Member from each of the three Scandinavian countries has died:

ROLF BULL ENGELSTAD of Norway,
GÖSTA FORSSELL of Sweden, and
CHRISTIAN BAASTRUP of Denmark.

I mention them in the order in which they left us. These three men were our friends and they were famous far beyond the borders of their home countries.

BULL ENGELSTAD was still young — but 47 years of age — when he died. He had for 10 years been director of the Norwegian Radium Hospital.

BULL ENGELSTAD was a most gifted man. During the last 15 years he had been the leading spirit in the crusade against cancer in Norway. He possessed a clear intellect, was an excellent speaker and was splendid in debate.

For many years radiotherapy was rendered subservient to other branches. It seemed as if this branch of medicine were lacking in independence. Its practitioners had always to ask their colleagues in other branches — "What shall we do?" — and as often as not had to be content to work with 'the crumbs which fell from the rich man's table' — the absolutely hopeless cases. This was especially true of the first generation of radiologists. In Norway BULL ENGELSTAD was a pioneer in this field. He broke away from the usual rut and led his speciality resolutely to the fore; he did this so ably and well that he earned recognition not only in Norway, but throughout Scandinavia and in many other parts of the world.

Norway has lost one of her great sons and the radiologists of Scandinavia a fine associate and colleague.

GÖSTA FORSSELL:

I bow my head in reverence when I mention his name.
I bow my head in gratitude when I think of his personality.
I bow my head in humility when I recall his work.

During the first half century of the history of radiology he left his mark on that branch of medicine. To outline his contribution would be impossible; I only wish to mention a few details to illustrate his great work both as a therapist and as a diagnostician.

In 1912 he introduced the radiological treatment of uterine cancer. Only his ability, his conviction and his enormous initiative could make the world-wide change in the method of treatment within the short space of time in which this occurred. In 1910 WERTHEIM had published his operative results, the fruits of a long life's work; in spite of this, FORSSELL advocated radium therapy and at once realized its great and epoch-making possibilities.

FORSSELL's investigations of the function of the stomach, notably on the mechanical comminution and mixing of the food by means of the independent movements of the mucous membrane, based on extensive anatomic studies, will always stand out as his main work; this which he continued and extended throughout his whole lifetime.

More than 200 papers covering the entire field of roentgen diagnostics and therapy saw the light of day in his study. There is practically no field within radiology which FORSSELL had not considered, and he always carried out his investigations with the thoroughness and care which characterize the great research workers.

Who does not remember the work of 1918 on the mortal wound of King Karl XII; here again he was the prime mover.

I remember the last time we were together at Djursholm. On that occasion the late Professor CHIEVITZ made a speech in honour of GÖSTA FORSSELL in which he emphasized his supremacy both as a therapist and as a diagnostician, and said that it was as if two great men were united into one.

Then there was the organization of the speciality, the building up of medical radiology as an independent subject at the Scandinavian universities. As already pointed out, at most European universities radiology was a secondary subject taught by surgical and medical professors. FORSSELL was aware that if radiology were to grow and be extended, it had to be an independent subject. Here lies, perhaps, FORSSELL's greatest contribution.

His personality was most striking. He was a torch-bearer, and when he had lectured at our Congresses, we always had a feeling that something of especial value had been communicated.

He was sharp, consistent and definite, but at the same time a lenient judge.

When, tonight, you come down to the museum of *The Old Town*, in one of the rooms of the Lord Mayor's House, you will find H. P. Holst's beautiful poem written at the time of King Frederik VI's death in 1839.

Whenever I think of GÖSTA FORSSELL, the King of the Realm of Radiology, this commemorative poem comes to my mind:

What loss, my Country, has thee hit![1]
Thy old King is asleep.
An active life, for labour fit,
Time's stream away did sweep.
Now broke his heart, whose tender strings
Stirred for all in his land.
Now broke his heart, whose gentle springs
Moved gently mind and hand.
Though he has made a future fit
For fruits which thou shalt keep,
What loss, my Country, has thee hit!
Thy old King is asleep.

[1] Translated by Professor Torsten Dahl, Aarhus.

CHRISTIAN BAASTRUP: Big and jovial, a child in his joy, a hero in disease and death.

It is due to BAASTRUP's initiative that this Congress is held at Aarhus. How I wish that he had been here to-day!

BAASTRUP made contributions to many different fields of medicine. He was one of the Danish founders of Acta radiologica; he was an organizer within his speciality and thanks to his initiative a number of radiologic posts were created at the municipal hospitals in Copenhagen. BAASTRUP designed an instrument for the continuous measuring of the roentgen dose. He was the first to produce a reliable, inexpensive and simple filter safety device. His name is attached to a disease of the spinal column; he published a large number of studies, his greatest contributions lying I think in the field of Medical History.

He was always present at the Scandinavian Congresses; he knew everybody and everybody liked him. We deeply regret that our old friend CHRISTIAN BAASTRUP is not present with us to-day.

ROLF BULL ENGELSTAD,
GÖSTA FORSSELL,
CHRISTIAN BAASTRUP,

We shall remember you with reverence and gratitude!

This was an epoch of the history of radiology. Our profession, however, has a future as well and it is this future we shall now consider.

The programme of scientific work which we are to go through during the coming days is both extensive and multifarious. Diagnostic roentgenology — the recognition of pathologic changes by means of roentgen rays — is as old as the rays themselves.

A few months, or I might even say a few days, after the discovery of roentgen rays, the new branch of medicine had gained ground.

On the day when the discovery was three months old, the Americans, who often have an eye for things off the beaten track, roentgenographed the heart of a child who was also exactly three months old on that day.

Since then, enormous developments have taken place. The radiologists of those days had to be content with taking roentgen photographs of the outline — the contour — of the heart, but at this Congress we are going to hear about the roentgenographic examination of the inside of the heart. We thus realize that we have during the last fifty years experienced development, almost incomprehensible in magnitude.

At first, and for many years afterwards, roentgenograms could only be made of the bones of the arms and legs, but to-day we are going to hear of methods of examining the tissues which surround the bones — the muscles, fat, veins and arteries; in a few years it may even be possible to roentgenograph the nerves. We may be able to ascertain whether frayed nerves actually exist — although this as yet belongs to the future.

The advances in medicine which have been made during recent years have been enormous but at the same time very costly to the community. In my opinion it is of immense importance that, by the exchange of experiences, we learn to draw the line as to what we are able and what we are unable to do; in this way we may spare our patients unnecessary examinations and the community unnecessary expense.

In cancer therapy we are still struggling to make patients seek treatment at an early phase of the disease and this aim must never cease. Much may be achieved if only patients do not come too late, which is, unfortunately, often the case. It has largely fallen to the lot of the radiologists to take the lead in this propaganda campaign, which appeals equally to patients and physicians. We hope that the campaign may continue and bear good fruit.

During recent years many branches of cancer therapy have been placed under radiotherapy, for example, a large portion of chemotherapy — the treatment with all the new substances which have been developed since it was discovered during the first World War, quite accidentally, that mustard gas exerted considerable effects on certain disorders of the lymph nodes.

Considering that about one-sixth of the papers which are to be read before this Congress deals with these new substances and related problems, we may, with justification, look forward to further developments in this field.

There are large numbers of diseases — generalized disorders, as we call them technically — which from the very onset involve all parts of the organism. So far, we have never been able to do anything to cure these diseases, but with the new substances in mind, we may occasionally foreshadow possibilities. It is as if we were catching sight of and just touching something, although not yet able to lay our hands on it and hold it fast. We are, however, steering towards the goal.

During the previous generation it was, perhaps a little contemptuously, said about the roentgenogram that it was only a shadow of the truth. Recently, the President of a local branch of the Danish Medical Association has said that we must be glad that the roentgenogram was, after all, the shadow of truth. This alone is a great thing, for truth is our principal aim.

I express the hope that this Congress may be of benefit to you all, that it may give initiative and hope, and that the words '*Never give up*', invisibly embellished over the Radium Centre at Aarhus, may become the motto of the Congress.

SCIENTIFIC COMMUNICATIONS.

Wednesday, June 13, 1951.

ROLF WEYDE: Laminography in the examination of patients with pulmonary tuberculosis.

T. DENSTAD: Planigraphy in pulmonary tuberculosis. (To be published in Acta tuberc. Scandinav.)

H. ØDEGAARD: The roentgenologic picture in chronic, non-specific fibrosis of the middle lobe. With special regard to the value of planigraphy. Acta radiol. 37 (1952), 17.

J. FRIMANN-DAHL: Planigraphy in calcified foci of the lungs (To be published — in Norwegian — in the Journal of Oslo City Hospitals).

PER AMUNDSEN: Planigraphy in Müller's and Valsalva's experiments.

JOHANNES ZIMMER: Planigraphy of the temporal bone. Acta radiol. 37 (1952), 419.

POUL ANDERSEN: Tomography in carcinoma of the maxillary antrum.

A. FRANTZELL: Roentgen examination of the soft tissues of the legs (To be published in Modern Trends in Diagnostic Radiology — Mc Laren).

J. FRIMANN-DAHL: Examinations of the soft tissues of the chest. Acta radiol. 37 (1952), 246.

J. RAVN-BYBERG and H. E. LESCHLEY JACOBSEN: Arteriography of the legs.

B. NORDENSTRÖM: Unilateral blocking of the pulmonary artery.

F. O. LÖFGREN: Carotid angiography in the diagnosis of spontaneous intracerebral haemorrhage. (To be published in Acta Radiologica.)

HANS IDBOHRN: Tolerance of the kidneys to contrast medium in renal angiography.

CARL WEGELIUS and J. LIND: The importance of exposure time as a diagnostic gain in angiocardiography. Acta radiol. 39 (1953), 177.

S. MUSTAKALLIO: The treatment of cancer of the breast with simple tumour extirpation and roentgen irradiation.

A. SCHEEL: Some prognostic factors, particularly biopsy in carcinoma of the breast. Acta radiol. 39 (1953), 249.

S. KAAE: The value of pre-operative roentgen irradiation in operable breast cancer. Acta radiol. 37 (1952), 568.

JENS NIELSEN: The organization of radiotherapy. Acta radiol. 37 (1952), 329.

FOLKE JACOBSSON: Teleradium treatment of laryngeal carcinoma at Radiumhemmet, Stockholm. Acta radiol. 38 (1952), 143.

B. JØRGSHOLM: Preliminary experiences with podophyllin in the treatment of skin carcinoma. Acta radiol. 37 (1952), 150.

I. SALLINEN: Erfahrungen mit der Röntgenbehandlung der phlyktenulären und tuberkulösen Augenkrankheiten (To be published in Klin. Monatsblätter für die Augenheilkunde. — Festschrift Löhlein).

W. PAGH SPERLING: "Snapping Finger". Roentgen treatment and experimental production. Acta radiol. 37 (1952), 74.

Thursday, June 14, 1951.

O. NORMAN: Hysterographically visualized radionecrosis following intra-uterine radiation of cancer of the corpus of the uterus. Acta radiol. 37 (1952), 96.

R. STEINERT: A compression apparatus for urography. Acta radiol. 38 (1952), 212.

R. STEINERT: Effect of enemata on contrast excretion in urography. Acta radiol. 38 (1952), 30.

H. ELTORM and E. D. BARTELS: Prolapsus mucosae pylori (To be published in Gastroenterology).

P. A. BLINKENBERG: Roentgen findings in hemorrhagia ventriculi (To be published — in Danish — in Nord. Med.).

CARL SANDSTRÖM (together with ÅKE GIDLUND): The post-operative emptying mechanism of the stomach (To be published in Acta radiol.).

P. G. K. BENTZON: On the pathogenesis of local malacia.

SEVED RIBBING: Hereditäre multiple Epiphysenstörungen und Osteochondrosis dissecans. Acta radiol. 36 (1951), 397.

FOLKE KNUTSSON: Diabetic arthropathy. Acta radiol. 36 (1951), 114.

MARCUS SCHALIMTZEK: Roentgenologic examination of the function of the lumbar spine. Acta radiol. 37 (1952), 141.

E. BENGTSSON: Pelvimetry — a simple method.

C. WEGELIUS: The determination and correction of optic sharpness in photofluorography.

E. EBBEHØJ: The safety factor in ultrasoft roentgen irradiation. Acta radiol. 37 (1952), 241.

K. LIDÉN and M. LINDGREN: Radiation hazards during cholangiographic examinations. Acta radiol. 38 (1952), 1.

J. BICHEL: Chemotherapy of cancer. Acta radiol. 36 (1951), 437.

P. BASTRUP-MADSEN: Action of some anti-neoplastic chemotherapeutic agents on cell division. Acta radiol. 36 (1951), 452.

J. KIELER: Nitrogen mustard therapy in Hodgkin's disease, lympho-reticulosarcomatosis and lymphatic leukemia. Acta radiol. 36 (1951), 461.

P. BJERRE-HANSEN and J. BICHEL: Triethylene melamine therapy in Hodgkin's and other malignant diseases. Acta radiol. 36 (1951), 469.

C. DEDEN: The demonstration of cancer cells in the urine as a diagnostic aid. Acta radiol. 37 (1952), 487.

A. M. NIELSEN: Cytological changes in vaginal smears in radium and roentgen irradiation of uterine carcinoma and their prognostic significance. Acta radiol. 37 (1952), 479.

C.-E. JOHANSON, GUSTAF ÖSTLING and R. V. GÅSSTRÖM: Treatment of uterine cancer with radioactive cobalt (Co^{60}). Acta radiol. 36 (1951), 324.

O. PETERSEN: Some clinical and histologic observations on 'precancerosis' of the portio vaginalis uteri. Acta radiol. 38 (1952), 49.

P. E. ANDERSEN: Diabetes and cancer of the endometrium.

E. RATJEN and B. M. HANSEN: Investigations on the optimal illumination of viewing cabinets. Acta radiol. 38 (1952), 447.

M. TEVES, T. TOL and W. J. OOSTENKAMP: The Philips roentgen image amplifier.

CARL KREBS: Raw egg yolk as a supplement to the roentgen treatment of osteogenic sarcomas in children.

Friday, June 15, 1951.

Visit to the Aarhus Radium Centre.

The Association decided to hold its next meeting in Helsinki, Finland, in June 1952.

The following officers were elected for the next period.

President:	Prof. SAKARI MUSTAKALLIO,	Helsinki, Finland
Members of the Board:	Prof. P. FLEMMING MÖLLER,	Denmark
	Prof. CARL KREBS,	Denmark
	Dr. W. EDGREN,	Finland
	Dr. KAI MALMIO,	Finland
	Dr. C.-E. JOHANSON,	Finland
	Dr. Y. LASSILA,	Finland
	Dr. G. PETERSEN,	Iceland
	Prof. T. DALE,	Norway
	Dr. J. FRIMANN-DAHL	Norway
	Prof. H. AHLBOM,	Sweden
	Prof. O. OLSSON,	Sweden
Deputy Members of the Board:	Dr. KRISTIAN OVERGAARD,	Denmark
	Dr. O. ARHO,	Finland
	Dr. A. SCHEEL,	Norway
	Prof. E. LINDGREN	Sweden
Treasurer:	Prof. FOLKE KNUTSSON,	Sweden

Karl Sandström
Secretary-General

PROCEEDINGS OF THE 18TH CONGRESS OF THE NORTHERN ASSOCIATION OF MEDICAL RADIOLOGY

(NORDISK FÖRENING FÖR MEDICINSK RADIOLOGI)
HELD AT HELSINGFORS, FINLAND, 18TH–20TH MAY, 1952

LIST OF OFFICERS

Organization Committee:

President: Prof. SAKARI MUSTAKALLIO.
Dr. A. O. ARHO.
Dr. W. EDGREN.
Dr. G. FAGERSTRÖM.
Dr. Y. LASSILA.

Secretaries: Dr. C. E. JOHANSON.
Dr. K. MALMIO.

Ladies Committee:

President: Mrs. LEA MUSTAKALLIO.
Mrs. ELINA ARHO.
Mrs. GRETA EDGREN.
Mrs. ANN MARIE HEIKEL.
Mrs. DORA JOHANSON.
Mrs. TYYNE LASSILA.
Mrs. ELVI MALMIO.
Mrs. ISMEME SALLINEN.
Mrs. MARCELLE VAENERBERG.

Honorary Presidents of the Congress:

Dr. ERIK DE FINE LICHT,	Denmark
Dr. ILMARI SALLINEN,	Finland
Dr. AXEL SCHEEL,	Norway
Prof. ERIK LINDGREN,	Sweden

Secretaries of the Congress:

Dr. HELGE ELTORM,	Denmark
Dr. ROLF KÖHLER,	Finland
Dr. HAAKON ØDEGAARD,	Norway
Dr. SÖLVE WELIN,	Sweden

The Congress was held at the Commercial High School. The President Prof. S. MUSTAKALLIO delivered the following speech of welcome:

Ladies and Gentlemen,

Now that we are assembled for the 18th Congress of the Northern Association of Medical Radiology, it is a great pleasure to me to see that so many of you have accepted the invitation to come to the far North. I bid you all most heartily welcome.

During the past year, two members of the Northern Association of Medical Radiology have passed from our midst.

Dr. STIG LINDHOLM, 51-year-old, Radiologist of Kullbergska Sjukhuset, Katrineholm, took part in several of our Meetings, including the last Congress in Helsingfors. During the last years of his life he struggled against a severe illness which he bore with great patience and bravery. We remember him as a capable and efficient radiologist and a good comrade.

Dr. ARVID LUNDQVIST, 57-year-old, Director of the Roentgen Department, Sundsvall's Lasarett, died after a long illness which, during the last years of his life, turned him into a secluded invalid and prevented his participating in our Meetings. Before illness undermined his health he was considered to have a promising career ahead of him. He published a number of scientific articles, mostly of a technical nature, and contributed lectures to the Northern Congresses. To those who worked with him before his health gave way he will be remembered as a gifted radiologist and a good friend.

Let us honour the memory of our dead colleagues by a short silence.

* * *

We radiologists are fortunate in being able to work in a field which, as far as may be judged, belongs to one of the most rapidly developing branches of medicine. Those of us who have taken part in numerous Nordic Congresses will no doubt remember some of the addresses which were given during the early days of radiology. I myself well recall the addresses given by FORSSELL, HEYERDAHL, BAASTRUP, BERVEN and others in the opening stages of radiology when they themselves helped to start the particular branch of science which we now represent.

The present Congress is of special note for the reason that the younger generation of radiologists is now beginning to come forward. The oldest generation of all is not represented here to-day, but as a representative of a somewhat later one, we are glad to see Professor GÖSTA JANSSON, to whom we extend a special welcome.

Medical radiology is no older than this. Its early development has been unusually rapid, and it would appear as though this development were going ahead at the same rate, both as regards therapy and diagnostics. Radiology has become a central branch of medicine. Its growth has in fact been so rapid that the authorities have had difficulty in keeping step. As far as I know there is a shortage of radiologists and roentgen staff in all the Northern countries; the supply of trained specialists is not equal to the demand. Equally, the instrumentarium does not meet the requirements of the present day — at least, not in Finland. This fact is not surprising if one follows the statistics of development in hospital roentgen departments. In our own case, the burden of work has enlarged by about 25 per cent per annum. It is obvious that staffs and instrumentaria cannot increase at the same rate, certainly not in the case of hospitals which are restricted by an unwieldy state budget. The burden of work in the roentgen departments has increased much more quickly, generally speaking, than in any of the other hospital departments.

All this is only intended to illustrate the significance of roentgen examinations and of radiotherapy and the valuation of these particular provinces.

The extreme importance of the roentgen examination is also emphasized by the fact that small plants for roentgen examination are now widely used by provincial doctors. It should not be long until every such practitioner has his own miniature roentgen set, chiefly for the purpose of examining bone fractures and lungs. It must be admitted that

these sets greatly increase the diagnostic possiblilities of medical practitioners, but although this general method of roentgen examination by non-specialists has had to be accepted by roentgenologists it must also be realized that it creates new conditions with regard to instruction and the use of precautionary measures. On the other hand, roentgen diagnostics and radiotherapy are rapidly becoming special branches. Methods of examination and treatment are becoming more complicated and the results attainable, higher. As a practical consequence of this, roentgen diagnosis and radiotherapy each form separate entities. It is, nevertheless, essential that radiologists in general retain a good working knowledge of each particular branch, as no doubt considerable time will elapse before radiology can be divided up into all its sections.

A new introduction to the science of radiology is the use of radioactive isotopes. The position of these in radiology is still somewhat unclear although their association has already become definitely established.

From what has been said, it is clear that many problems within the field of radiology still await solution. If we face the fact of these difficulties it will be easier to overcome them and it is of importance to remember that development is, and should be, proceeding. In the course of its advancement, radiology has made use of a large number of mechanical aids with which to discover and explain bodily function and sickness. It is easy to forget the rôle of machinery in the field of radiology and to accept the current view that mechanization is only applicable to the material side of life. In radiology, one often sees that the use of a machine leads to an understanding of hitherto inexplicable sickness. The history of roentgenology will also become the history of roentgenologic apparatus. The more highly perfected technical inventions become, the easier will it be to understand the details of the human body and the better shall we be able to help human beings towards full bodily health.

The victorious progress of radiology will assuredly continue and it may be said without exaggeration that, to a great extent, in radiology lies the future of medicine.

These Nordic Congresses are of assistance in helping us to follow the rapid development of radiology, as it is always better to work in co-operation than to fumble ahead alone. Here may be said to lie the chief significance of our Congresses. Welcome!

SCIENTIFIC TRANSACTIONS

During the previous Congress it had been decided that at every subsequent Congress a special lecture should be given in memory of GÖSTA FORSSELL. It would be the task of the Committee to appoint a scientist or research worker to deliver this lecture. The Committee had unanimously invited Prof. GÖSTA JANSSON to give the first GÖSTA FORSSELL lecture, for which the latter had chosen the subject 'Re.note neurologic action on the digestive tract.'

OLOF NORMAN, Lund (By invitation): Cholangiography — technique and diagnostic possibilities.

MAX SIURALA, Helsingfors: Correlation between roentgenography and gastroscopy with special regard to the diagnosis of gastritis.

KRISTINA EKENGREN, Stockholm: Roentgenologic examination of mechanical difficulties in defecation. (To be published in Acta radiol.)

SAKARI MUSTAKALLIO, Helsingfors: Cancer of the lungs — diagnostics and roentgen treatment.

O. W. HUSEBYE, Oslo: Fluororoentgenography and cancer of the lungs.

MARJA KOULUMIES, Helsingfors: Smoking and pulmonary carcinoma. Acta radiol. 39 (1953), 255.

PENTTI ERMALA, Helsingfors: The distribution and the absorption of tobacco tar in the organism.

CARL SANDSTRÖM, Stockholm: Concerning contrast media for the kidneys, heart and vessels, and their toxicity. Acta radiol. 39 (1953), 281.

HAAKON ODEGAARD, Oslo: Dionosil — a new contrast medium for bronchography.

C.-E. JOHANSON, Helsingfors: Method and contrast medium for hysterosalpingography.

LENNART KJELLMAN, Stockholm: A new instrument for urethrocystography (read by Prof. K. LINDBLOM). Acta radiol. 38 (1952), 440.

INGMAR FERNSTRÖM, Stockholm: Percutaneous retrograde arteriography of the iliac artery as a diagnostic means in obstetrics and gynecology. (Published in more detailed form in Acta radiol. 38 (1952), 247.)

HAAKON ODEGAARD, Oslo: Roentgen examination after thoracotomy.

ULF RUDHE, Stockholm: Variations of the heart volume in the newborn period.

ALVARI AHO, Helsingfors: Metastases in the heart.

P. E. HEIKEL, Helsingfors: Roentgenologic osseous changes in leukemia in children.

RASMUS STENSTRÖM, Helsingfors: The importance of tomography in changes in the cervical spine.

OVE MATTSSON, Stockholm: Apparatus for centering roentgen tubes.

EDMUND KAISER and ERIK DE FINE LICHT, Copenhagen: A photometer for determination of exposure time in diagnostic work. Acta radiol. 38 (1952), 167.

CARL WEGELIUS, Stockholm: Roentgenologic application of high kilovoltage technique.

MARTIN LINDGREN, Lund: Some results of measurements of the radiation risks during roentgenologic work. Acta radiol. 38 (1952), 1.

EIVIND MYHRE, Oslo: Malignant lymphomata. }
AXEL SCHEEL, Oslo: Malignant lymphomata. } (to be published in Acta radiol.)

SVEN HULTBERG, Stockholm: Local enzymatic treatment of radiation necrosis of the skin. Acta radiol. 39 (1953), 343.

KAI NIELSEN, Aarhus: Attempts at reducing the toxic side effects of nitrogen mustard. Acta radiol. 39 (1953), 337.

HARALD TEIR, Helsingfors: Cancer caused by repeated injections of extracts from normal tissues.

ANTERO VOUTILAINEN, Helsingfors: Twenty-four hours variations of the mitotic frequency in malignant tissue.

The Association decided to hold its next Congress in Oslo, Norway, at the beginning of June, 1955. The Committee reserved the right, however, to fix the Congress for the same time in 1954, should any possibility of so doing present itself.

Professors ÅKE ÅKERLUND, Stockholm, and GÖSTA JANSSON, Helsingfors, were unanimously elected honorary members.

The following officers were elected for the next period:

President:	Dr. J. FRIMANN-DAHL,	Oslo
Members of the Board:	Prof. P. FLEMMING-MOLLER,	Denmark
	Prof. CARL KREBS,	Denmark
	Prof. S. MUSTAKALLIO,	Finland
	Dr. W. EDGREN,	Finland

	Dr. G. Petersen.	Iceland
	Prof. T. Dale,	Norway
	Dr. A. Scheel,	Norway
	Dr. E. Poppe,	Norway
	Dr. R. Weyde,	Norway
	Prof. H. Ahlbom,	Sweden
	Prof. O. Olsson,	Sweden
Deputy Members of the Board:	Dr. E. de Fine Licht,	Denmark
	Dr. Y. Lassila,	Finland
	Dr. T. Denstad,	Norway
	Prof. E. Lindgren,	Sweden
Secretary-General:	Dr. Sölve Welin,	Sweden

Carl Sandström
Secretary-General

BOOK REVIEWS

RÖNTGENUROSKOPIE. NIERENBECKEN UND -KELCHE, HARNLEITER, BLASE, HARNRÖHRE. Von G. W. Günther. 46 Seiten, 86 Abb. Georg Thieme Verlag, Stuttgart 1952. DM 13.50.

The author stresses the value of fluoroscopy in retrograde pyelography, a measure not entirely unknown perhaps to most roentgenologists.

A number of interesting observations are reported and discussed; many earlier interpretations in the field of functional pathology, and which — as pointed out by the author — are to a large extent explainable by the technique used in the performance of retrograde pyelography, are made the subject of valuable criticism. The results would have been more informative and more reliable if the technique of examination had been varied more and if the differential diagnosis had also been based upon the use of other methods, such as renal angiography. In some parts, especially in the discussion of details other than purely anatomic observations, the presentation is vague. References to studies by other authors are sometimes erroneous.

Olle Olsson.

RADIOLOGIC DIAGNOSIS OF THE LOWER URINARY TRACT. By D. E. Beard, W. E. Goodyear and H. S. Weens. 150 pages, 280 illustrations. Charles C. Thomas. Springfield 1952. $ 6.50.

The authors have produced a book the general form of which is that of an atlas. In spite of its small size it gives fairly complete reports of the history, anatomy and radiologic technique, as well as the normal and pathologic conditions of the lower urinary tract in male adults and children.

The urethra and the bladder are examined separately. For urethrography an iodized oil and for cystography 10 per cent 'skiodan' or 5 per cent sodium iodide solutions are employed. Unfortunately, the authors have not differentiated the prostatic urethra and the intravesical contrast band described by KNUTSSON in 1935. In this important detail the drawings in Figs. 10, 21, 37 and 93 are incorrect. The necessity of employing an aqueous medium for the roentgen examination of the bladder, for which an oily medium is unsuitable, is well pointed out. The authors stress the importance of obstructions in the bladder neck and prostatic urethra to the urinary flow in children but have not emphasized the value of micturition examinations.

The book is clear and easy to read; the recommendation of the use of oil in urethrography, however, gives it a somewhat old-fashioned approach.

Nils P. G. Edling.

BOOKS RECEIVED

We acknowledge with thanks under this heading books received for review, which we trust will be regarded as a sufficient mark of appreciation of the courtesy of the sender. The reviews of selected items will appear as soon as opportunity affords.

GRUNDRISS DER ELEKTROKYMOGRAPHIE. PHASENANALYSE UND RAUMKYMOGRAPHIE DES HERZENS. Von K. Heckmann. Georg Thieme Verlag, Stuttgart 1952.

DIE ANGIOGRAPHIE ZUR ERKENNUNG, BEHANDLUNG UND BEGUTACHTUNG PERIPHERER DURCHBLUTUNGSSTÖRUNGEN. Von H. W. Pässler. Georg Thieme Verlag, Stuttgart 1952.

THE 1952 YEAR BOOK OF RADIOLOGY. The Year Book Publishers, Inc., Chicago.

BOLLETINO DELLA ACCADEMIA MEDICA PISTOIESE "FILIPPO PACINI" ANNO XXIII, VOL. I., SETTEMBRE 1952.

CRANIOGRAFIA ESAME SENZA MEZZI DI CONTRASTO E CON CONTRASTO (CISTERNO-ENCEFALOGRAFIA, VENTRICULOGRAFIA, ANGIOGRAFIA CEREBRALE) — ROENTGENOLOGICAL EXAMINATIONS WITHOUT AND WITH CONTRAST MEDIUMS (CISTERNOGRAPHY AND ENCEPHALOGRAPHY, VENTRICULOGRAPHY, CEREBRAL ANGIOGRAPHY). By prof. Mario Lenzi. Casa Editrice Cappelli, Bologna.

MODERN MASS SPECTROMETRY. By G. P. Barnard. Physics in Industry, The Institute of Physics, London 1953.

Index to Volume 39

Roentgen Diagnosis

Nervous System

Pagina

Aqueduct of Sylvius 117
Acoustic tumours — angiography..... 265
Displacement of third ventricle 377

Digestive Tract

Abdominal radiography in infants 6
Hypopharyngeal carcinoma..... 17
Hepatic venography..... 89
Visualization of ulcerative processes 98
Rectogenital pouch 105
Duodenohepatic reflux..... 169
Iodine contrast in stomach wall 219
Oesophagus in funnel chest 273
Gastric motive function 353

Heart and Vessels

Coarctation of aorta..... 47
Hepatic venography..... 89
Angiocardiography 177
Abdominal aortography 205
Vertebral angiography..... 265
Heart in funnel chest..... 273
Contrast media 281
Aneurysms of splenic and renal arteries 385

Lungs, Pleura and Mediastinum

Pulmonary carcinoma..... 255
Lungs in funnel chest..... 273

Bones and Joints

Lumbosacral transitional vertebrae..... 225
External carotid apertare 308
Epitriquetrum, hypotriquetrum and lunatotriquetrum 401
Troell-Junet syndrome..... 485

Uro-Genital System

Rectogenital pouch 105
Internal uterine endometriosis 126
Contrast media 281
Diodone in urography..... 299
Aneurysm of renal artery 385
Urethrography in male 453

Radiotherapy

Hypopharyngeal carcinoma 17
Cortisone in roentgen dermatitis 73
Survival rate calculation 78

Pagina

Plasmocytoma of vagina..... 83
Carcinoma of uterine cervix 141
Survival time in breast cancer..... 161
Embryonal liposarcoma 242
Prognostic factors in breast carcinoma .. 249
Cerebellar medulloblastoma 323
Isotopes in carcinoma of cervix uteri.... 415
Iodine-concentrating thyroid carcinoma .. 423
Thyroid and radioactive iodine..... 477

Chemotherapy and Hormone Therapy

Radiochimie à la radiobiologie 64
Cortisone in roentgen dermatitis 73
Testosterone in disseminated breast cancer 161
Nitrogen mustard..... 337
Enzymatic treatment of radiation necroses 343

Radiobiology

Radiochimie à la radiobiologie..... 64
Time-picture relation study with autoradiography 137

Tumour Biology

Smoking and pulmonary carcinoma..... 255
Iodine-concentrating thyroid carcinoma .. 423

Technique

Roentgen Examination

Contrast levelling in projection printing.. 38
Visualization of ulcerative processes 98
Release mechanism for exposure 131
Exposure rate in angiocardiography..... 177
Artefacts in autoradiography..... 192
Abdominal aortography 205
Contrast media for kidneys, heart and vessels 281
Method of determining radioactive material in vivo..... 317
Catheter in percutaneous arteriography .. 368
Magnifying viewer for photofluorographic films 412
Dichromatic absorption radiography 437
Microradiography 494
Time-marker for urograms..... 499
Correct concentration of barium contrast media 501

Radiotherapy

Intercavernous roentgen irradiation..... 57
Iridium-192 teletherapy unit..... 231
Isotopes in carcinoma of cervix uteri.... 415

Obituary

Pagina
Hugo Ahlbom 1

Editorial

17th Congress of Northern Association of Medical Radiology 507
18th Congress of Northern Association of Medical Radiology 514

Book Reviews

Tomographie de la base du crâne 87
Selected papers from Royal Cancer Hospital and Chester Beatty Research Institute 87
Zerebrale Angiographie 88
Mass, lipids, pentose nucleoproteins and proteins determined in nerve cells by microradiography 174
Pagina
Adequate stimulation for chemical composition of retinal ganglion cells 175
Gynäkologische Strahlentherapie 176
Urethrography in male with Umbradil-Viscous U 261
Roentgen examination in acute abdominal diseases 262
Enzephalographie 263
Psychological effects of radiation at cellular level 264
Osteosklerose und Knochenmarkfibrose .. 435
Wirbelverschiebung in der Lendengegend.. 435
Physics and medicine of the upper atmosphere 436
Dizionario technico di radiologia 436
Röntgenuroskopie 519
Radiologic diagnosis of lower urinary tract 519

List of Authors

(r) indicates "reviewed only"

Appelberg, Gustaf, 83.

Beard, D. E., 519 (r).
Berven, Elis G., 1.
Bogsch, Albert, 219.
Borell, U., 141.
Boström, Harry, 137.
Brattgård, Sven-Olof, 174 (r), 175 (r), 494.
Brégeat, P., 87 (r).
Brocher, J. E. W., 435 (r).

Castellano, Francesco, 377.

David, M., 87 (r).
Di Chiro, Giovanni, 117.
Duhamel, J., 64.

Edling, Nils P. G., 273.
Egmark, A., 423.

Farr, R. F., 323.
Fischgold, H., 87 (r).
Fossati, Franco, 436 (r).
Freundlich, H. F., 231.
Frimann-Dahl, J., 262 (r).

Getz, Bernhard, 308.
Gilg, Ejnar, 299.
Goodyear, W. E., 519 (r).
Gyllenswärd, Å., 6.
Günther, W., 519 (r).

Hallberg, O., 161.
Hallén, O., 494.
Hasner, E., 225.
Haybittle, J. L. 231.
Hultberg, Sven, 343.
Hydén, Holger, 174 (r), 494.

Jacobsen, H. H., 225.
Jacobson, Bertil, 437.
Johansson, Sven A. E., 317.

Kaae, Sigvard, 434 (r)
Kepp, Richard Kurt, 176 (r).
Klami, Paavo, 98.
Koulumies, Marja, 255.
Krayenbühl, H., 88 (r).

Lampe, Carl Erik, 169.
Larsson, Lars-Gunnar, 423, 477.
Laur, Albert, 435 (r).
Liliequist, Bengt, 126.
Lilja, Bengt, 353.
Liljestrand, A. 423.
Lind, John, 177.
Lindgren, Erik, 117, 205.
Lindvall, Nils, 17.
Lodin, Herman, 6.
Longuet, D., 64.

Marshall, A. H. E., 73.
Mattsson, Ove, 38, 131, 412, 501.
Moore, Sherwood. 485.
Morales, Olallo, 261 (r), 453.
Mykland, O., 6.

Nielsen, Kai, 337.
Nohrman, Bengt A., 78, 161.
Odeblad, Erik, 137, 192.
Odman, Per, 47.
Olsson, Olle, 265.
O'Rahilly, Ronan, 401.

Paterson, Edith, 323.
Piffault, C., 64.

Ragnhult, Inger, 423, 477.
Richter, H. R. 88 (r).
Romanus, Ragnar, 261 (r), 453.
von Ronnen, J. R., 385.
Ruggiero, Giovanni, 377.

Sandkühler, Stefan, 435 (r).
Sandström, Carl, 281.
Sangster, M., 57.
Schalimtzek, M., 225.
Scheel, Axel, 249.
Schiersmann, Otto, 263 (r).
Seldinger, Sven Ivar, 368.
Skanse, Bengt, 317.
Skjoldborg, Henning, 242.
Snorrason, E., 225.
Stodtmeister, Rudolf, 435 (r).
Sylvén, Bengt, 161.

Tori, Giulio, 89.
Tudway, Robert C., 415.

Wallden, Lennart, 105.
Weens, H. S. 519 (r).
Wegelius, Carl, 177.
Willner, Olof, 499.

Å, Ä, see A.
Ö, Ø, see O.

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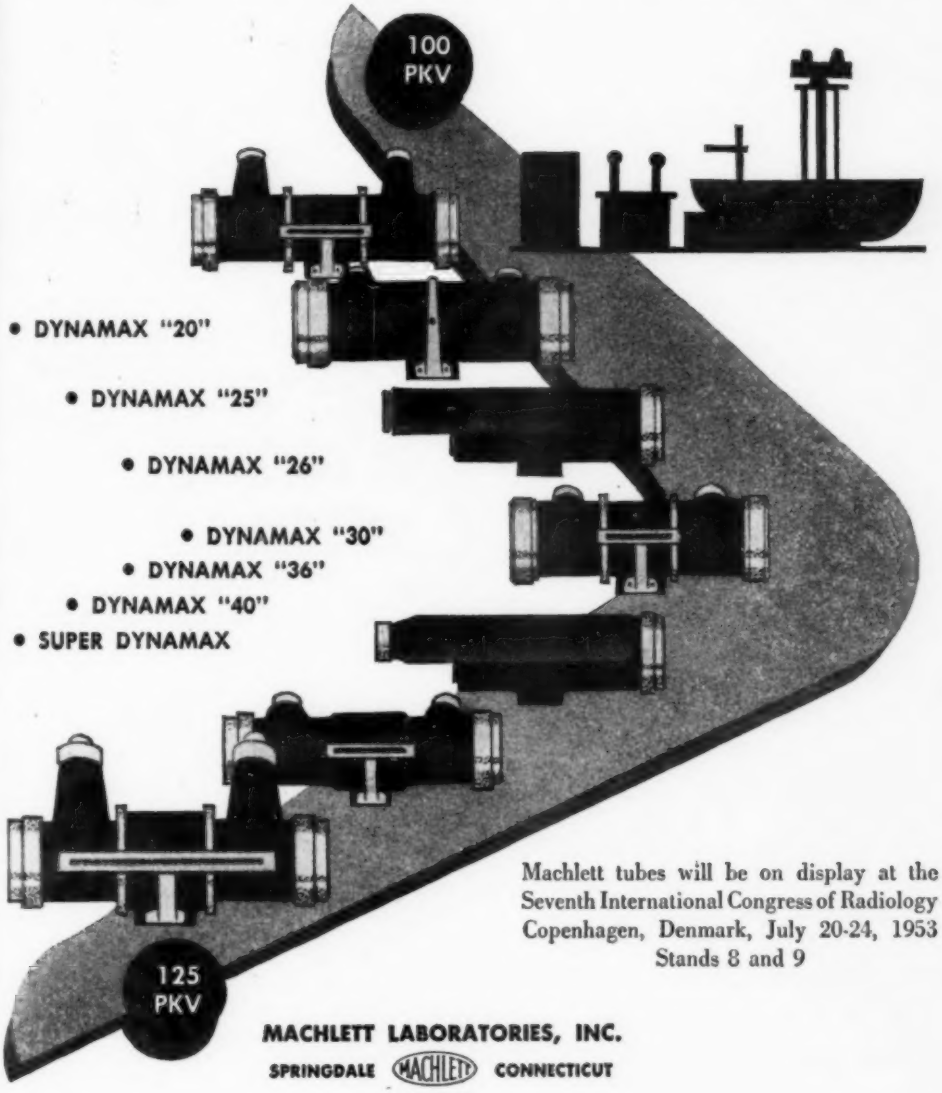

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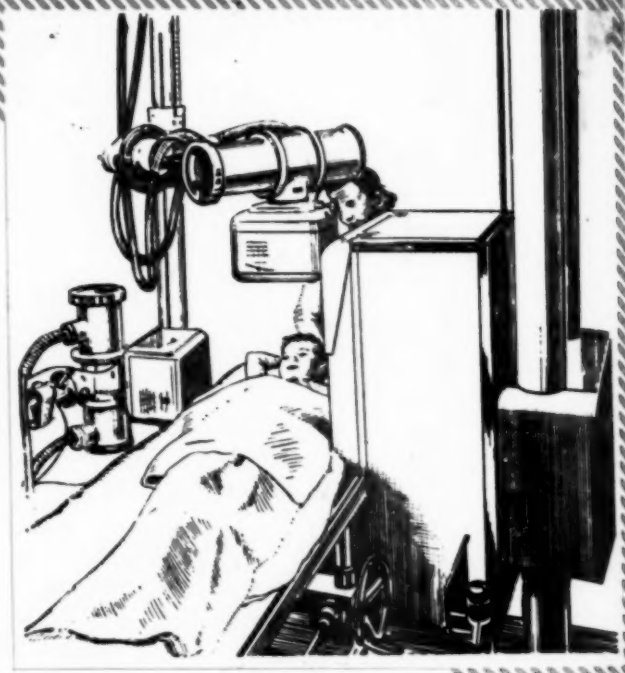

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